hp 218A

HEWLETT-PACKARD COMPANY / OPERATING AND SERVICE MANUAL

218A

DIGITAL DELAY GENERATOR

hp 218A

CERTIFICATION

THE HEWLETT-PACKARD COMPANY CERTIFIES THAT THIS INSTRUMENT WAS THOROUGHLY TESTED AND INSPECTED AND FOUND TO MEET ITS PUBLISHED SPECIFICATIONS WHEN IT WAS SHIPPED FROM THE FACTORY.

hp FURTHER CERTIFIES THAT ITS CALIBRATION MEASUREMENTS ARE TRACEABLE TO THE NATIONAL BUREAU OF STANDARDS TO THE EXTENT ALLOWED BY THE BUREAU'S CALIBRATION FACILITY.

OPERATING AND SERVICE MANUAL

MODEL 218A

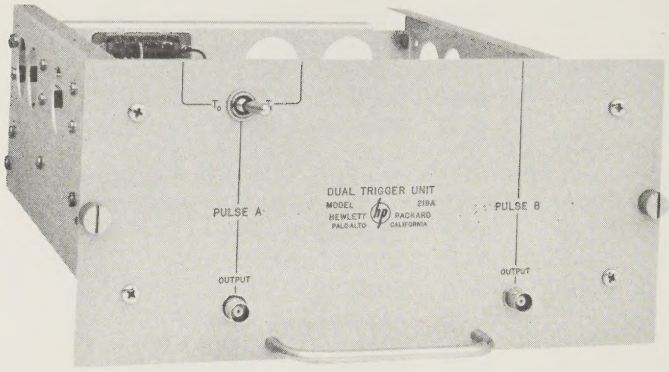
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DIGITAL GENERATOR

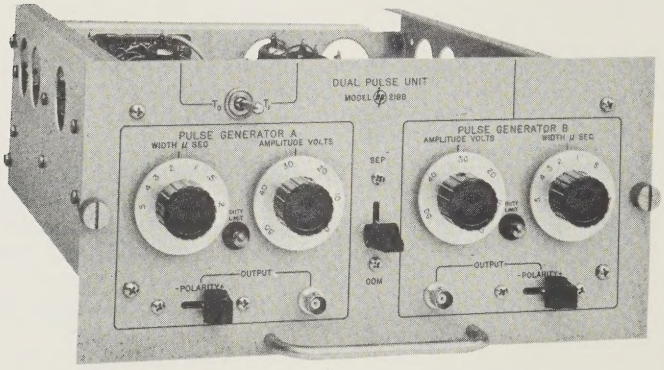
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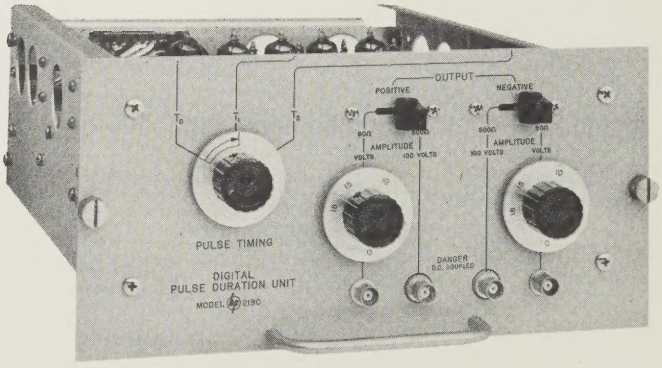
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Plug-In Unit ⓗp Model 219A



Plug-In Unit ⓗp Model 219B



Plug-In Unit ⓗp Model 219C

Figure 1-1. Plug-In Units

SECTION I
GENERAL INFORMATION

1-1. DESCRIPTION.

1-2. The Ⓗ Model 218A Digital Delay Generator provides precise, jitter-free time delays from 1 μsec up to 10,000 μsec with respect to a random trigger signal. Two delay periods, T_1 and T_2, are independently selectable in digital steps of 1 μsec. In addition, continuous interpolation between the 1 μsec steps is possible.

1-3. The over-all accuracy of each time delay is within ±0.1 μsec ±0.001% of the selected delay (when triggered by a random signal).

1-4. Time intervals are initiated by an internal rate generator or by external signals from 0 to 10 kc. Single delay periods are obtained by depressing the MANUAL TRIGGER push-button.

1-5. The instrument delivers SYNC OUTPUT pulse selectable to coincide with the beginning of the delay period T_0, or with the end of the delay period T_1 or T_2.

1-6. The Model 218A is useful for checking radar, loran, DME and Tacan systems range calibration. Resolution or time delays of circuits can be measured with extreme accuracy within a fraction of the time used with previous methods. Measuring or simulating fast timing gates and other applications are possible, by using one of the several companion plug-in units.

1-7. PLUG-IN UNITS.

1-8. The associated plug-in units generate pulses of various kinds, occuring at T_0, T_1 or T_2, thus providing the output pulses of the basic unit Model 218A.

1-9. DUAL TRIGGER UNIT-Ⓗ MODEL 219A.

1-10. Two positive trigger pulses A and B of approximately 50 volts amplitude driven from a 50-ohm source are available. The pulses have a width of approximately 2 μsec and a rise time of 0.1 μsec. The leading edge of pulse A occurs at T_0 or T_1 as selected by a switch. The leading edge of pulse B occurs at T_2.

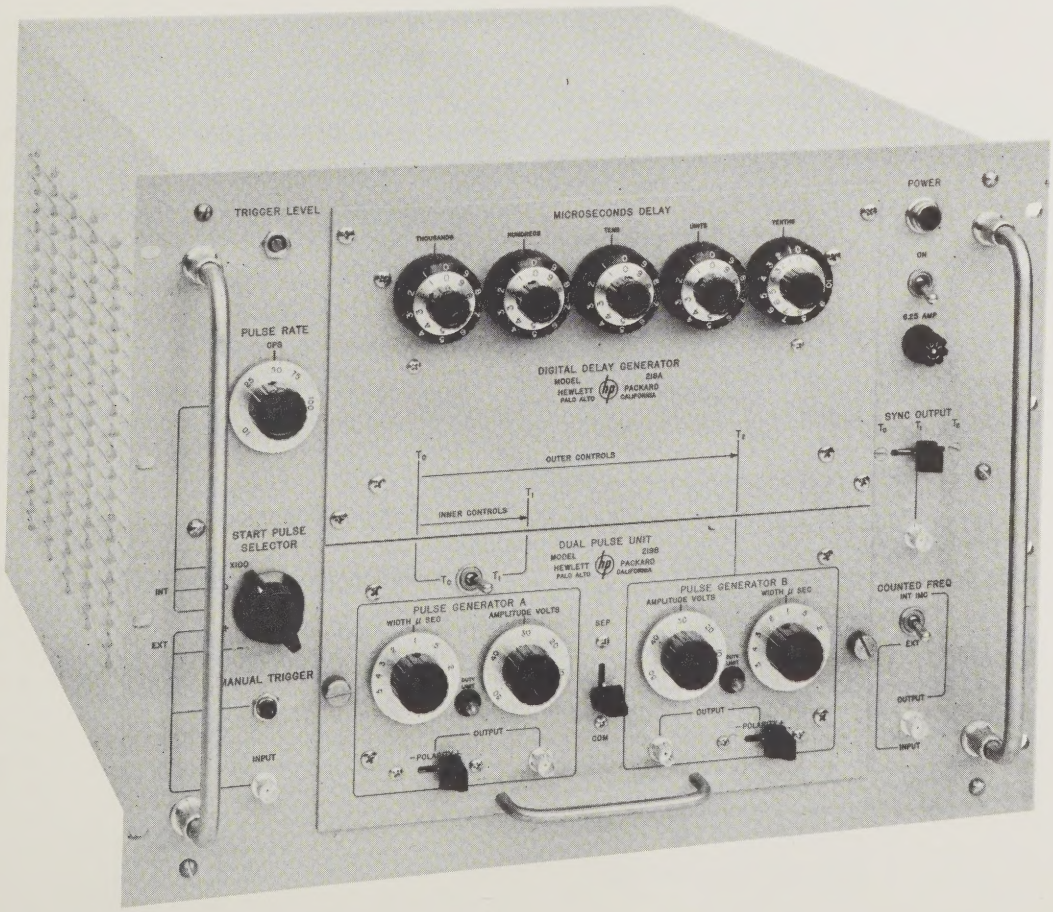


Figure 1-2. Model 218A Digital Delay Generator

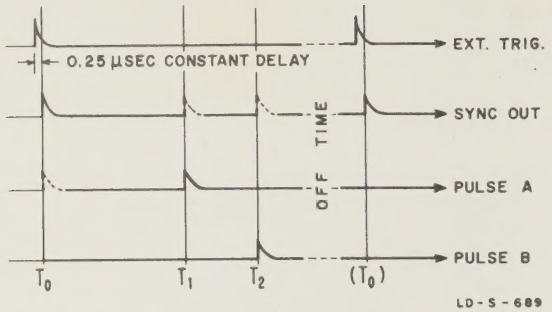


Figure 1-3. Time Plan Model 219A Plug-In Unit

1-11. DUAL PULSE UNIT - ℗ MODEL 219B.

1-12. Plug-in unit Model 219B generates two high powered pulses. The amplitude of each pulse can be adjusted individually from 0 to 50 volts. A switch associated with each output selects the polarity of the pulse.

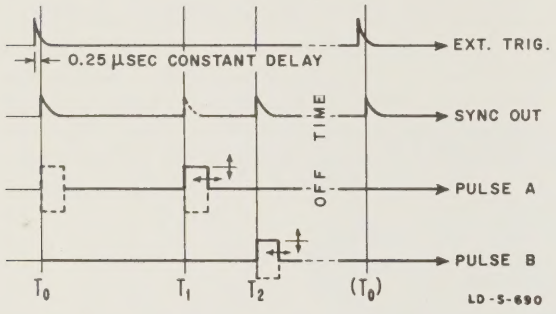


Figure 1-4. Time Plan Model 219B Plug-In Unit

1-13. The pulse width is variable from 0.2 - 5 µsec with a rise time of 0.06 µsec. The pulses are available separately or from a common jack. The source impedance is 50 ohms for both output modes.

1-14. DIGITAL PULSE DURATION UNIT - ℗ MODEL 219C.

1-15. The unit Model 219C delivers a fast rise-time pulse with its start and stop time digitally controlled by the Model 218A. The output supplies a positive and negative going pulse simultaneously of 0.03 µsec rise and decay time.

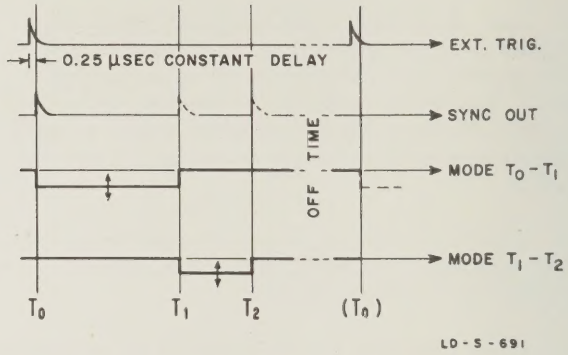


Figure 1-5. Time Plan Model 219C Plug-In Unit

1-16. One set of output jacks provides a pulse (+ and -) of variable amplitude, 0 to at least 15 volts peak into an open circuit from a 90-ohm source impedance. The second set of output jacks supplies a pulse (+ and -) of fixed amplitude, minimum 90 volts peak into an open circuit from a 500-ohm source impedance.

1-17. INSTRUMENT IDENTIFICATION.

1-18. Hewlett-Packard uses a two-section eight-digit serial number (000-00000). If the first three digits of the serial number on your instrument do not agree with those on the title page of this manual, change sheets supplied with the manual will define differences between your instrument and the Model 218A described in this manual.

Table 1-1. Specifications

℗ MODEL 218AR DIGITAL DELAY GENERATOR

Time Interval Range: (T_0 to T_1 and T_0 to T_2) 1 to 10,000 microseconds, accuracy ±0.1 μsec, ±0.001% of time interval selected.

Digital Adjustment:
1 to 9,999 microseconds in 1 μsec steps.

Interpolation:
Continuously adjustable control adds 0 to 1 microsecond to digital setting.

Trigger:
Internal: Rate Generator adjustable 10 c/s to 10 kc/s in 3 decade ranges.

External:

Sine Wave: 5 to 40 volts
10 c/s - 100 c/s
2 to 40 volts
100 c/s - 10 kc/s

Pulse: Positive or Negative, switch selectable; 0 cps to 10 kc, 2 to 40 volts peak. For Rise Time of 0.05 μsec or less, delay between external input trigger and T_0 is less than 0.5 μsec.

Front Panel Screwdriver control provides adjustable trigger point over a limited range to optimize triggering on noisy signals.

Input Impedance: 400K ohms shunted by less than 75 pf.

Manual: Push button initiates single pulse cycle.

Jitter:
0.02 μsec or less.

Recovery Time:
70 μsec or 10% of selected interval whichever is greater.

Sync Output:
Positive Pulse:
Amplitude: 50 to 70 volts open circuit.
Source Impedance: 50 ohms, nominal.
Rise Time: 0.1 μsec
Width: More than 1.5 μsec.

Available at T_0, T_1, or T_2 as selected by a switch.

Internal 1 mc/s Time Base Output:
When counting internal 1 mc/s crystal oscillator, 1 volt positive pulses from 500 ohm source at a front panel connector are available for longer time interval duration.

External Counted Signal:
Range: 10 cps to 1 mc/s, sinusoidal; 0 to 1 mc/s positive pulses; (random or periodic)

Amplitude: 5 volts rms minimum: sine-wave, 10 c/s to 100 c/s.

2 volts rms minimum: sine-wave, 100 c/s to 1 mc/s.

2 volts peak, positive pulse

Input Impedance: 1 megohm shunted by 100 pf.

With external counted signal, delay becomes 1 to 9,999 periods in one periods in one period steps.

Accuracy: ±1 period, ±0.1 μsec

The delay in periods of the external counted signal, between pulse T_1 and T_2, is always the difference between the T_1 and T_2 MICROSECOND DELAY dial settings. The TENTHS dial is always calibrated in microseconds.

Power:
115 or 230 volts ±10%, 50 to 60 cps, 555 watts

Weight:
Net 74 lb (33.596 kg)

Dimensions:
14 in. high (35.56 cm), 19 in. wide (48.26 cm) 24 in. deep (60.96 cm). Depth behind panel 21-3/4 in. (55.25 cm).

℗ MODEL 219A DUAL TRIGGER UNIT

When plugged in Model 218A

Output:
Two pulses, A and B
Amplitude: 50 volts open circuit
Source Impedance: 50 ohms, nominal
Rise Time: 0.1 μsec
Width: More than 1.5 μsec

Timing:
Pulse A at T_0 or T_1 as selected by a switch.
Pulse B at T_2

Polarity:
Positive

Power:
Supplied by Model 218A

Weight:
Net 4 lb (1.016 kg)

Table 1-1. Specifications (Cont'd)

MODEL 219B DUAL PULSE UNIT When plugged in Model 218A	MODEL 219C DIGITAL PULSE-DURATION UNIT When plugged in Model 218A
Output: Two pulses, pulse A and B Timing: Pulse A - At T_0 or T_1 as selected by a switch Pulse B - At T_2 Amplitude: Individually adjustable, 0 to 50 volts peak open circuit, positive or negative polarity, available separately or from common jacks. Output Impedance: 50 ohms nominal, for both separate or common connection Width: Individually adjustable 0.2 to 5 μsec Rise Time: 0.06 μsec Power: Supplied by Model 218A Weight: Net 7 lb (3.178 kg)	Output: Starts at T_0, ends at T_1, or digitally delayed from T_0 to T_1 with start at T_1, end at T_2, as selected by a switch. Polarity: Positive and negative-going pulses with their most positive excursions clamped to chassis are available simultaneously. Amplitude: Adjustable, 0 to 15 volts peak or more, open circuit from 90-ohm source impedance; or 90 volts peak or more, open circuit from 500-ohm source impedance. Rise and Decay Time: 0.03 μsec for 90-ohm output Power: Supplied by Model 218A Weight: Net 5 lb (2.270 kg)

SECTION II
PREPARATION FOR USE

2-1. UNPACKING AND INSPECTION.

2-2. Unpack the instrument upon receipt and inspect it for signs of physical damage such as scratched panel surfaces, broken knobs, etc. If there is any apparent damage, file a claim with the carrier and refer to the warranty page in this manual.

2-3. REPACKING FOR SHIPMENT.

2-4. The following list is a general guide for repackaging an instrument for shipment. If you have any questions, contact your authorized Hewlett-Packard sales representative.

a. If possible, use the original container designed for the instrument.

b. Wrap the instrument in heavy paper or plastic before placing it in the shipping container.

c. Use plenty of packing material around all sides of the instrument and protect the panel with cardboard strips.

d. Use heavy cardboard carton or wooden box to house the instrument and use heavy tape or metal bands to seal the container.

e. Mark the packing box with "Fragile", "Delicate Instrument", etc.

Note

If the instrument is to be shipped to Hewlett-Packard Company for service or repair, attach to the instrument a tag identifying the owner and indicating the service or repair to be accomplished. In any correspondence be sure to identify the instrument by model number, serial prefix, and serial number.

2-5. POWER REQUIREMENT.

2-6. The Model 218A requires a power source of 115/230 volts ±10%, 50 to 60 cps, 555 watts.

2-7. POWER CABLE.

2-8. To protect operating personnel, the National Electrical Manufacturer's Association recommends that the instrument panel and cabinet be grounded. This instrument is equipped with a three-conductor power cable which, when plugged into an appropriate receptacle, grounds the instrument. The offset pin on the power cable three-prong connector is the ground pin.

2-9. To preserve the protection feature when operating the instrument from a two-contact outlet, use a three-prong to two-prong adapter and connect the green pigtail on the adapter to ground.

2-10. 230-VOLT OPERATION.

2-11. The Model 218A is normally wired for operation from a nominal 115-volt supply. Operation from a 230-volt source is easily accomplished by reconnecting the dual 115-volt primary windings of the power transformer from a parallel configuration to a series configuration using RT901 and RT902 to make the connection (see Power Supply Schematic Thermistors figure 5-22). RT901 and RT902 are used to limit the current surge to transformers T901 and T902, when instrument is first turned on. At the time of the change, replace F902, the 6.25 amp fuse with a 3.2 amp fuse for 230-volt operation.

2-12. INSTALLATION.

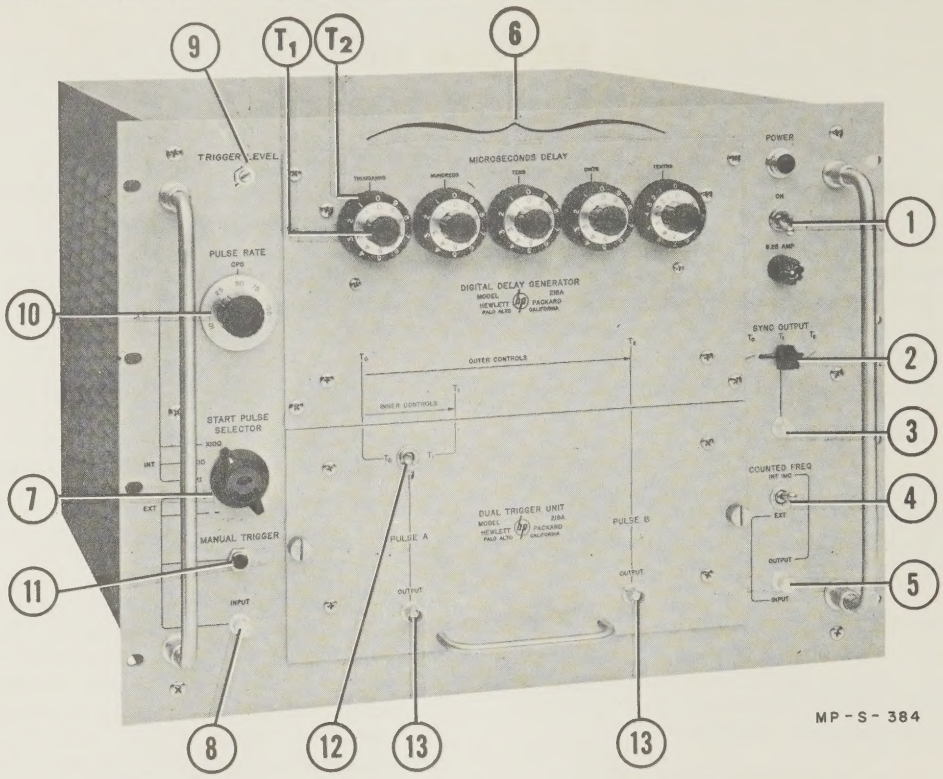
2-13. The Model 218A mounts in a standard 19-inch rack. It can also be operated on a work bench or table.

2-14. COOLING.

2-15. The Model 218A uses forced air cooling. The air intake and filter are located on the rear of the instrument. For proper ventilation, leave at least three inches of clearance behind the air intake. In addition, be certain that no other instruments discharge warm air into the intake of the Model 218A.

2-16. THERMO CUT-OUT SWITCH.

2-17. A thermo cut-out switch located on the center deck below the decade drawer (see figure 5-1) disconnects the instrument from the power line when the temperature within the unit becomes excessively high. The instrument will only operate again, after the thermo cut-out switch has been reset manually. To reset, remove the output plug-in unit and reach push button on the inner top right hand side.



1. Turn on power to instrument.
2. Select desired time for leading edge of Sync Pulse to appear at SYNC OUT jack (3).
3. SYNC OUT: Positive pulse approximately 50 volts amplitude. Rise time 0.1 μsec. Source impedance approximately 50 ohms. Leading edge occurs at (T_0, T_1, T_2) selected by switch (2).
4. Select frequency to be counted: INT 1 mc to select internal pulsed 1 mc crystal oscillator; EXT to use external signal fed into INPUT jack (5).
5. Counted frequency OUTPUT/INPUT jack. When switch (4) is Up, positive output pulses from the 1 mc oscillator are available at this BNC jack. Amplitude approximately 1 volt from a 500 ohm source impedance.
 When switch (4) is Down, an external frequency may be fed into this jack. Range 10 cps to 1 mc sine waves, or pulses at any rate below 1 mc. Amplitude 5 volts minimum; Input impedance 1 megohm, 100 $\mu\mu$f.
6. Select delays desired from 1.0 μsec to 10,000 μsec. Use red knobs to select T_1 and black knobs to select T_2. (A dial setting of 0000.0 gives a 10,000.0 microsecond delay.)
7. Select input signal source: External positive or negative pulse from input jack (8) or internal rate generator; Internal rate generator is in use whenever START PULSE SELECTOR is on X1, X10 or X100 position.
8. INPUT for external trigger.
 Pulse range: 0 to 10 kc, positive or negative 2 to 40 volts peak. For rise time less than 0.05 μsec the Delay between external input trigger and T_0 is 0.25 μsec $\pm$0.05 μsec.
 Sine Waves: 10 cps to 10 kc, Input Impedance approximately .5 megohm, 70 $\mu\mu$f.
 Recovery Time: 50 μsec or 10% of selected interval (6), whichever is longer.

Note: Maximum rate is restricted with long delays. See figure 3-2. Trigger level voltage may be adjusted with screwdrive adjust control (9).

9. Trigger Level: Adjust trigger level when using External Input (8). Maximum sensitivity approximately 1.5 volts rms when full cw, minimum sensitivity approximately 10 volts rms when full ccw.
10. Select internal rate generator frequency. Use this control in conjunction with the START PULSE SELECTOR (7).
11. Press push button to initiate single time intervals. SELECTOR switch must be in (+) or (-) position to use MANUAL TRIGGER - NO INPUT TO EXT TRIGGER JACK (8).
12. Select time T_0 or T_1 which will determine the time of the leading edge of OUTPUT PULSE A.
13. OUTPUT PULSE (A) and (B).
 Leading edge corresponds to time T_0 and T_2.
 Characteristics: Positive, 50 volts amplitude, rise time 0.1 μsec, source impedance approx. 50 ohms.

Figure 3-1. Model 218A/219A Front Panel Operating Controls

SECTION III
OPERATING INSTRUCTIONS

3-1. INTRODUCTION.

3-2. Section II contains information for setting up and operating the Model 218A. Different modes of operation in conjunction with the companion plug-in units are described. In paragraph 3-21 some applications of the Model 218A are discussed.

3-3. TURN-ON PROCEDURE.

3-4. Become familiar with the principle of operation before operating the instrument (see paragraph 4-2). The front panel operating controls are explained in figure 3-1. When setting the controls remember, that the repetition rate and the delay times are interdependent (see paragraph 4-3).

Note

Delay is 10,000 μsec, when all MICROSECOND DELAY dials of T_1 or T_2 are set to 0000.0. (Set to 9999 and $\frac{10}{10}$ this to preclude spurious pulses which may occur under certain conditions when set to 0000.0.) Be sure COUNTED FREQ switch (lower right-hand corner) is in position INT 1 MC, unless an external frequency is being counted.

3-5. OPERATION WITH PLUG-IN UNITS.

3-6. Different plug-in units provide output pulses for the Model 218A instrument (see paragraph 1-7). The operation of the Model 218A with its associated plug-in units is shown in figures 3-3 through 3-5. Operating the Model 218A with an external time base is indicated in figure 3-16.

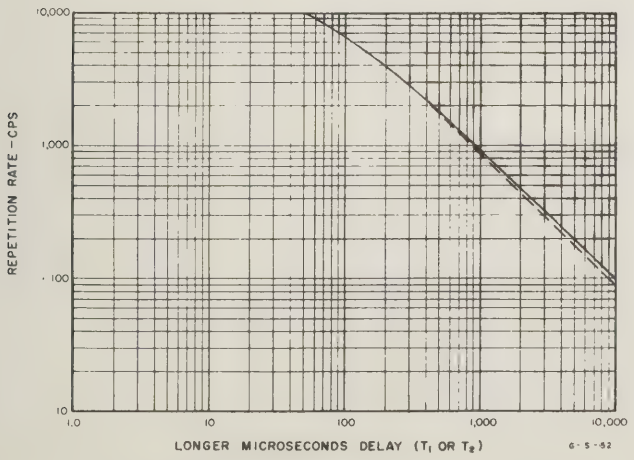


Figure 3-2. Repetition Rate Chart

3-7. MAXIMUM REPETITION RATE.

3-8. For maximum accuracy of the delay periods select a repetition rate, that allows an off-time of at least 10% of the longer delay period (T_1 or T_2). The instrument automatically reduces the actual repetition rate if a minimum off time of 50 microseconds between two time delay periods is not maintained (see figure 3-7). The dial reading of the internal (or external) repetition rate then indicates a rate that is higher than the actual repetition rate. The chart of figure 3-2 shows the maximum possible repetition rate for a given longer delay period (T_1 or T_2).

Note

When only <u>one</u> delayed pulse is being used (e.g. T_1) <u>set</u> the other delay (here T_2) to 0001.0. This will eliminate the possibility of the unused delay pulse accidentally being set to a delay longer than desired. As a result the repetition rate would be lowered internally.

3-9. CALCULATING MAXIMUM RATE.

3-10. The formula for the maximum repetition rate is:

$$\text{Max. } f_{rep} = \frac{10^6}{(T + 50)_{\mu sec}} \text{ in cps}$$

where: T = longer delay time (T_1 or T_2);
50 = rest time of 50 μsec.

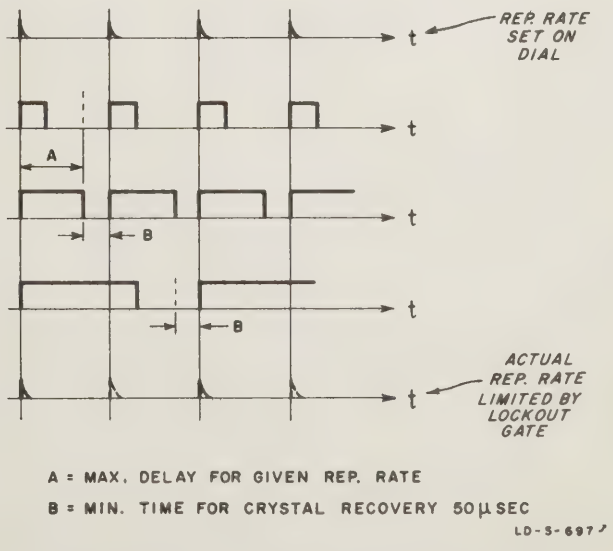
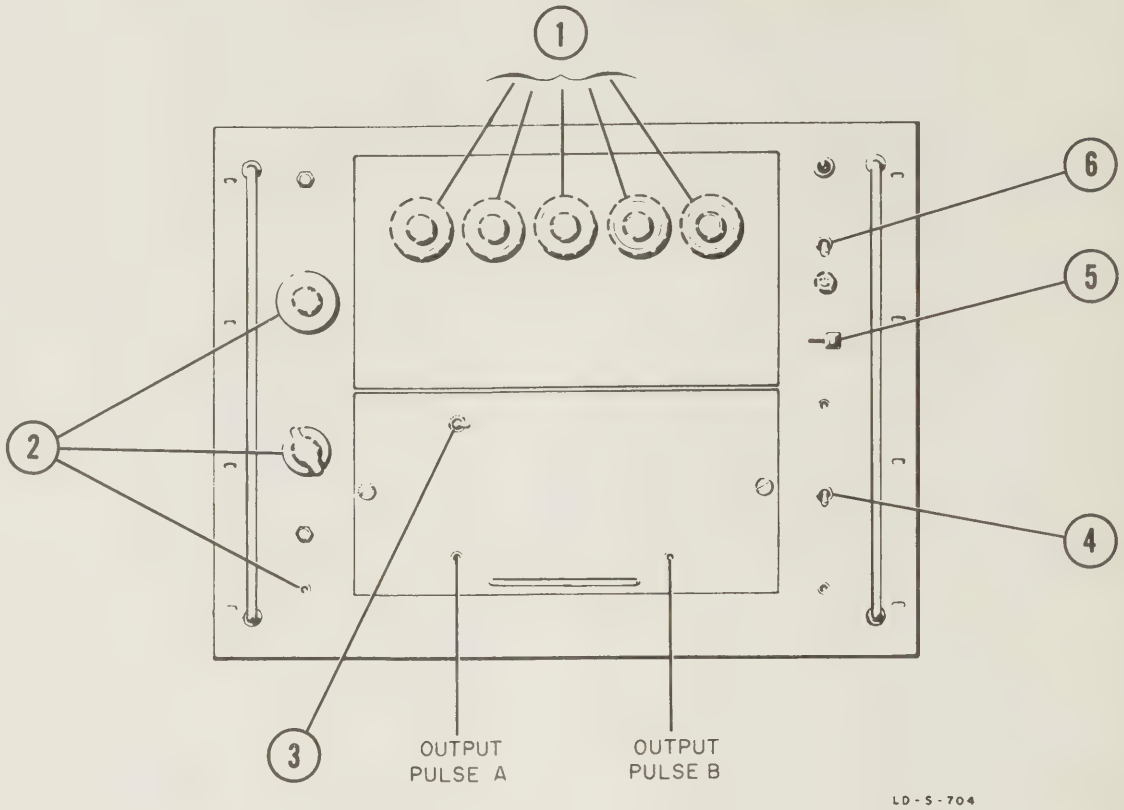


Figure 3-3. Limitation of Repetition Rate



1. Set MICROSECOND DELAY dials: T_1 on red controls; T_2 on black controls.

Note: T_1 or T_2 can be the longer delay, since they are independent.

2. Select Trigger Mode: Internal Repetition Rate or External Trigger.

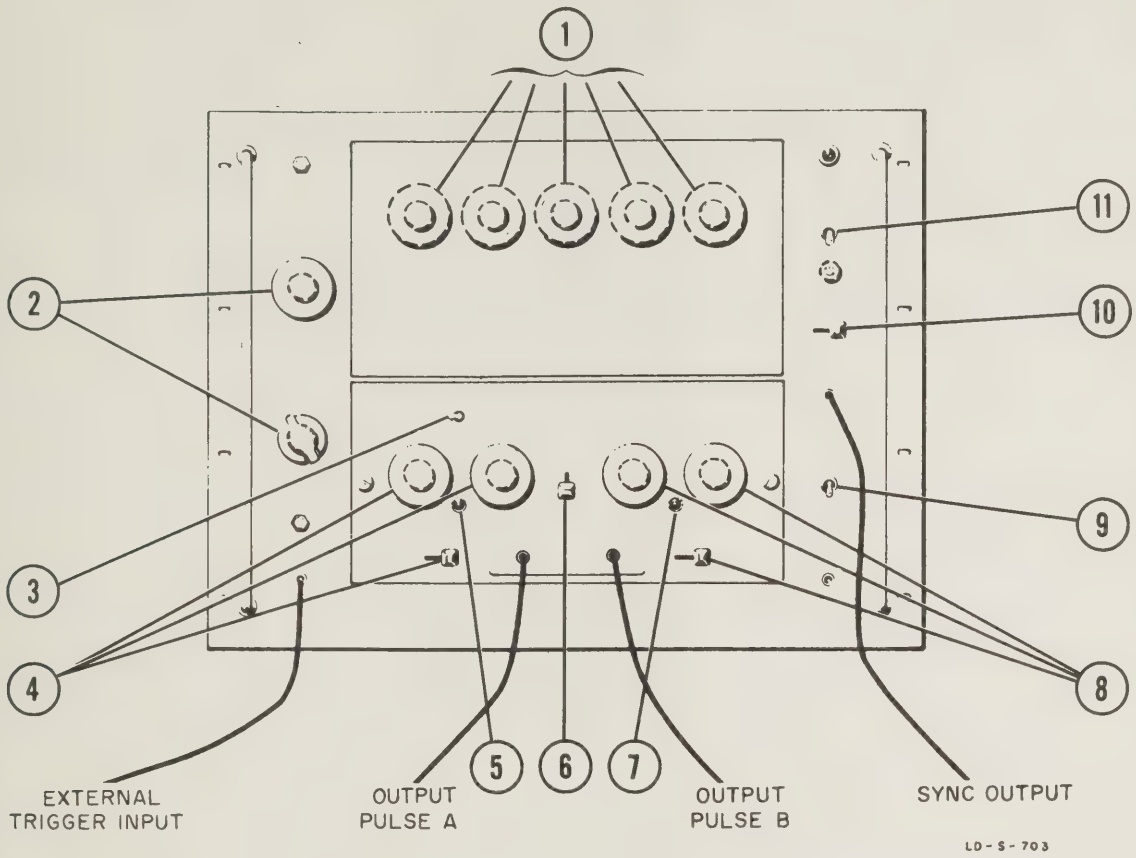
3. Set switch to desired output pulse (T_1 or T_0).

4. Set COUNTED FREQ switch to INT 1 MC.

5. Set SYNC OUTPUT selector switch to T_0, T_1 or T_2.

6. Turn ON instrument.

Figure 3-4. Model 219A Plug-In Operation



1. Set MICROSECOND DELAY dials: T_1 on red controls T_2 on black controls.

Note: T_1 or T_2 can be the longer delay, since they are independent.

2. Select Input Trigger Mode: Internal Rate Generator or External Trigger.

3. Select time of leading edge of Pulse A.

4. Select AMPLITUDE, WIDTH and POLARITY of output Pulse A.

5. Duty limit, if exceeded reduce pulse repetition rate or pulse WIDTH (see step 4).

6. Select output mode, SEP or COM. 50 ohm output in either position.

7. Duty limit, if exceeded reduce pulse repetition rate or pulse WIDTH (see step 8).

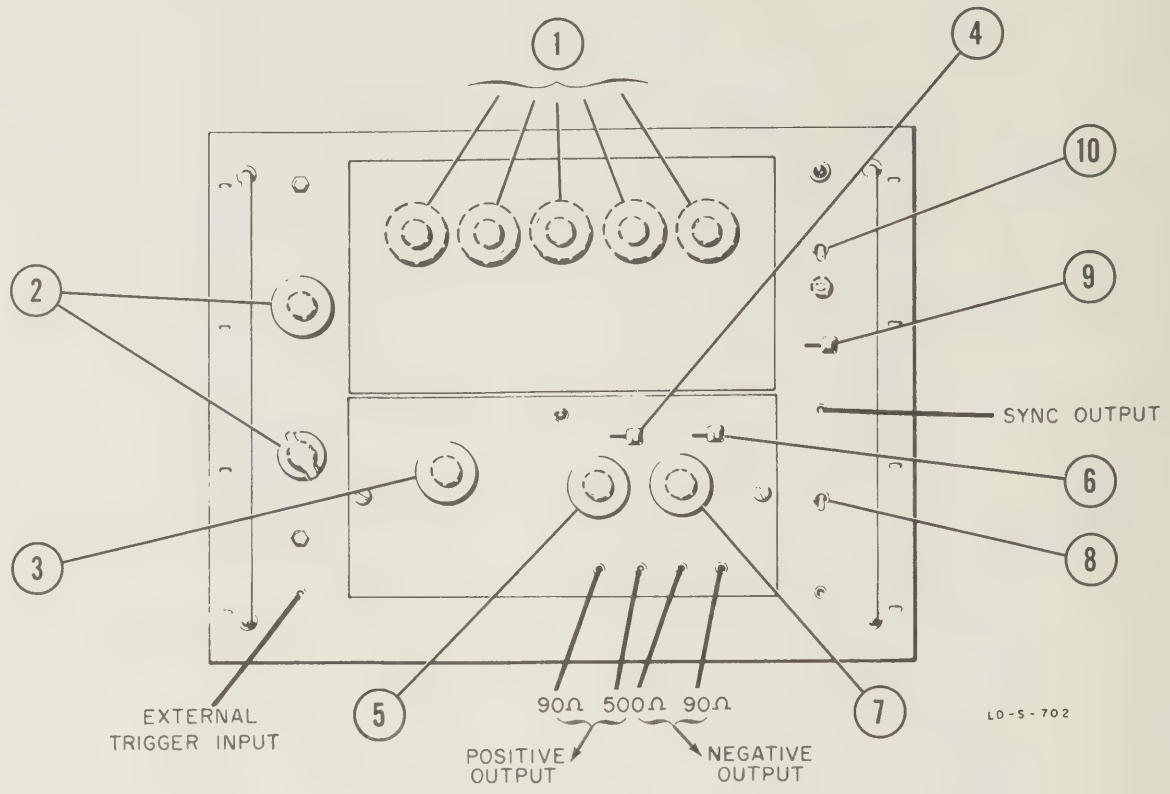
8. Select AMPLITUDE, WIDTH and POLARITY of output Pulse B.

9. Set switch to INT. 1 MC.

10. Select SYNC OUTPUT at T_0, T_1, or T_2.

11. Turn ON instrument.

Figure 3-5. Model 219B Plug-In Operation



1. Set MICROSECOND DELAY dials: T_1 on red controls, T_2 on black controls.

Note: T_1 or T_2 can be longer delay since they are independent, however pulse polarity will reverse.

2. Select Input Trigger Mode: Internal Rate Generator or External Trigger.

3. Select PULSE TIMING T_0 - T_1 or T_1 - T_2.

4. Select Output Impedance of POSITIVE OUTPUT:

 90 ohms, amplitude variable 0 - 15 volts (measured into open circuit).

 500 ohms, amplitude fixed -90 volts (measured into open circuit).

5. Set AMPLITUDE (for 90 ohm output).

6. Select Output Impedance for NEGATIVE OUTPUT:

 90 ohms, amplitude variable 0 - 15 volts, (measured into open circuit).

 500 ohms, amplitude fixed -90 volts, (measured into open circuit).

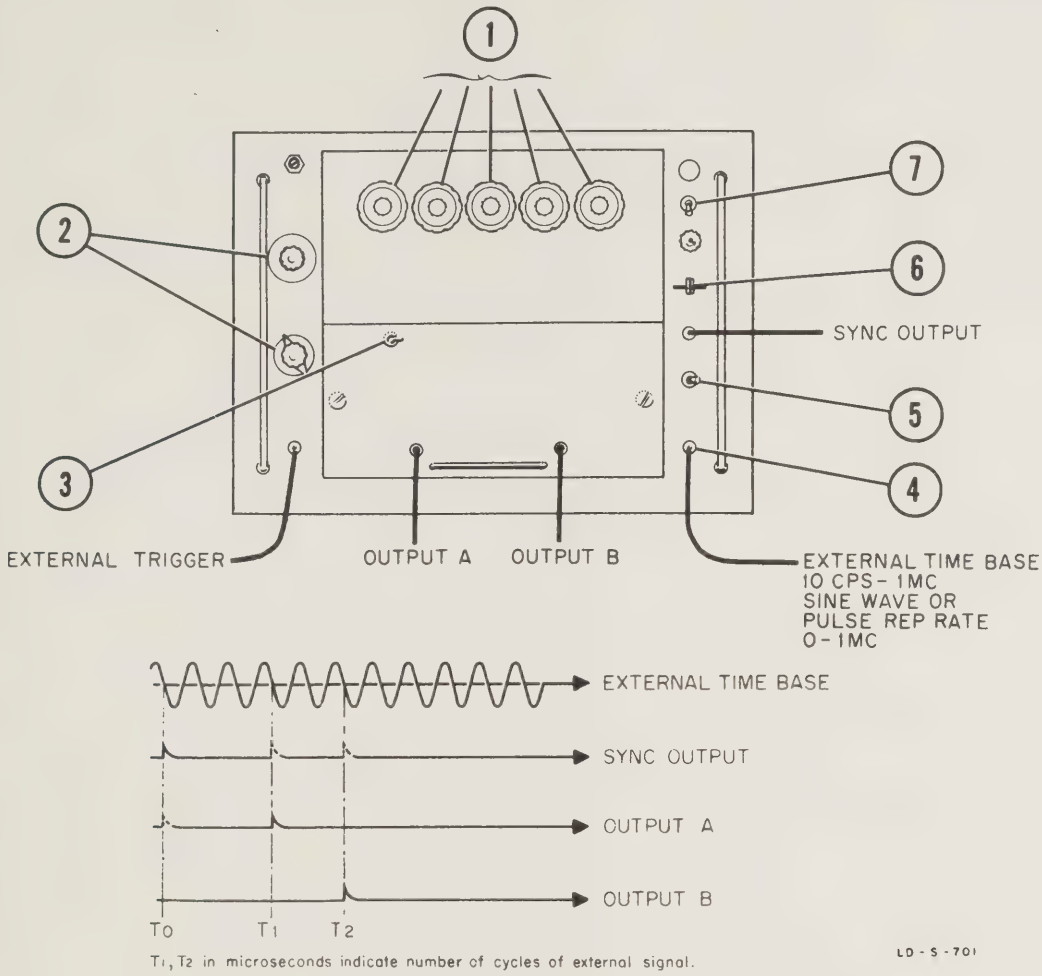
7. Set AMPLITUDE (for 90 ohm output).

8. Set switch to INT. 1 MC.

9. Select SYNC OUTPUT at T_0 - T_1 or T_2.

10. Turn ON instrument.

Figure 3-6. Model 219C Plug-In Operation



1. Set MICROSECOND DELAY dials: T_1 on red controls, T_2 on black controls.

Note: T_1 or T_2 can be the longer delay, since they are independent.

2. Select Trigger Mode: Internal Repetition Rate or External Trigger.

 There is a possible jitter of a maximum of one period with respect to the External Trigger unless the trigger is synchronized with an external time base.

3. Set switch to desired output pulse (T_0 or T_1).

4. Connect external time base signal.

5. Set COUNTED FREQ switch to EXT.

6. Set SYNC OUTPUT selector switch to T_0 T_1 or T_2.

7. Turn ON instrument.

Figure 3-7. External Time-Base Operation

3-11. The following examples illustrate the limitation of the repetition rate:

a. Time delay T = 450 μsec: Int. Repetition Rate = 1 kc. The maximum repetition frequency is computed:

$$\text{Max. } f_{rep} = \frac{10^6}{450 + 50} = 2000 = 2 \text{ kc}$$

With the above settings, the maximum repetition rate is higher than the set Int. Repetition Rate. The instrument operates properly.

b. Time delay T = 1450 μsec; Int. Repetition Rate = 1 kc. The maximum repetition frequency is computed:

$$\text{Max. } f_{rep} = \frac{10^6}{1450 + 50} = 667 \text{ cps}$$

With the above setting the maximum repetition rate is lower than the set Int. Repetition Rate. The instrument limits the actual repetition frequency internally to a lower value.

The correct Int. Repetition Rate can be computed for example (b) by allowing an off time of 10% of T.

$$\text{Int. Rep. Rate} = \frac{10^6}{1450 + 145} = 627 \text{ cps}$$

The maximum repetition frequency (667 cps) is now higher than the Int. Repetition Rate (627 cps). The instrument operates properly.

Note

Figure 3-2 shows a chart for selecting the maximum repetition rate possible for a given (longer) delay period (T_1 or T_2).

3-12. EXTERNAL TRIGGER AND JITTER OF TIME DELAY.

3-13. The jitter between T_0 and T_1, or between T_1 and T_2 is not affected by the external trigger signal and is always less than 0.001% ±0.1 μsec.

3-14. START OF TIME DELAYS.

3-15. There are two ways to trigger the Model 218A; i.e.: to initiate a time delay: 1) External Trigger 2) Internal Sync.

3-16. EXTERNAL TRIGGER.

3-17. Pulses or sine waves of maximum 10 kc trigger the Model 218A externally. Single delay periods are initiated by depressing the MANUAL TRIGGER pushbutton, with the START PULSE SELECTOR switch either in +EXT or -EXT.

Note

Refer also to figure 3-9 and to the specifications in the front of this manual.

3-18. INTERNAL SYNC OPERATION.

3-19. An internal repetition rate generator starts the delay period with the START PULSE SELECTOR switch in X1, X10, or X100. The repetition rate is continuously variable from 10 cps to 10 kc (PULSE RATE control interpolates between decades.) For limitation of repetition rate see paragraph 3-7.

3-20. The repetition rate can be lowered by connecting an external capacitor from pin 6 of V101A to pin 8 of J103 (testpoint). Set START SELECTOR switch to X100.

Rate:			Capacitor:	
1	to	10 cps	1.8 μfd/300	vdcw
.1	to	1 cps	18 μfd/300	vdcw

3-21. APPLICATIONS.

3-22. In combination with its various plug-in units, the Model 218A provides highly accurate time delays and different types of high-powered output pulses. This combination opens a wide area of new potential applications. In addition to various time measurements, the Model 218A and its associated plug-in units enable synthesizing of complex pulse forms.

3-23. DIGITALLY-TIMED TRIGGER PULSES.

3-24. MEASURING WAVEFORMS. The precision time delays obtainable with the Model 218A make it possible to calibrate waveforms (rise time, pulse width etc.) be modulating the intensity of the oscilloscope trace with the timed output pulse of Model 219A.

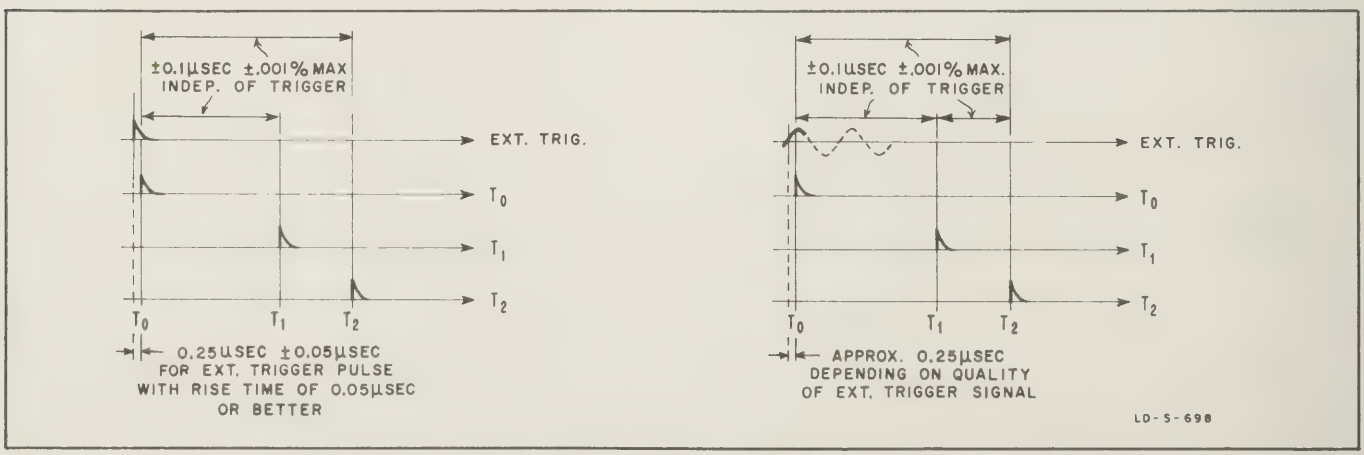
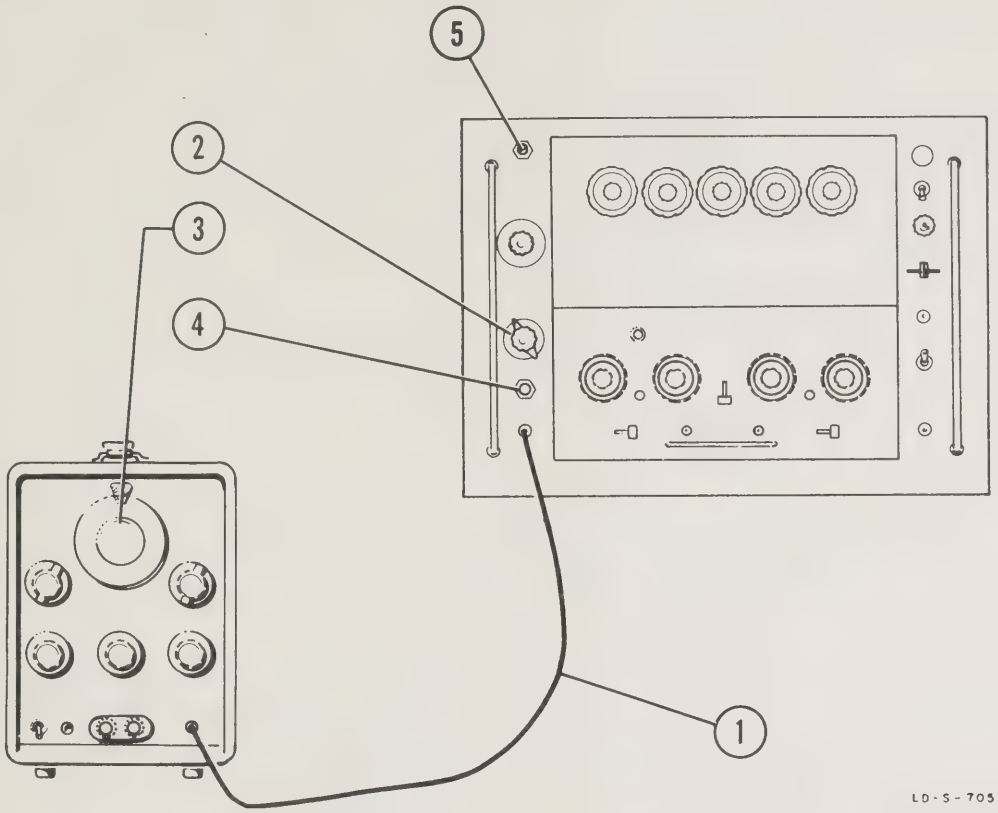


Figure 3-8. Delay and External Trigger



1. Connect External Trigger Source to External Trigger Input.

2. Set START PULSE SELECTOR to +EXT. or -EXT.

 Sine Wave: 5 volt rms for 10-100 cps
 2 volt rms for 100 cps to 10 KC

 Pulse: 2 to 40 volt peak positive or negative for 0 to 10 KC

Note: Delay between External Input Trigger and T_0 is 0.25 μsec ±0.05 μsec for a pulse rise time 0.05 μsec or less.

3. Select correct repetition range according to set MICROWAVE DELAY. (See figure 3-2.)

4. MANUAL TRIGGER.

5. TRIGGER LEVEL ADJUST, see INPUT SENSITIVITY CHECK of figure 4-5.

Figure 3-9. External Trigger Operation

3-25. Since the time interval is read off the MICROSECONDS DELAY dials of the Model 218A, the sweep time of the oscilloscope does not have to be calibrated. See figure 3-10.

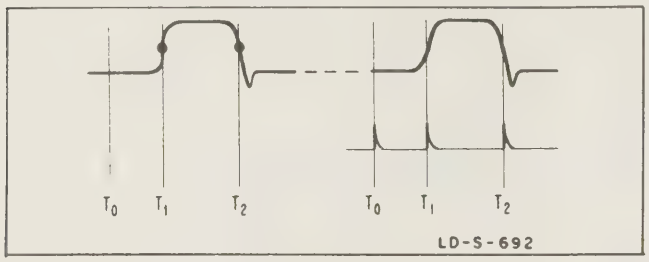


Figure 3-10. Measuring Waveforms

3-26. MEASURING DELAY TIMES: Delay lines can be measured conveniently and accurately with the Model 218A. Output pulse A (at T_0) is fed to the input of the delay line. The vertical input of the oscilloscope is connected to the output of the delay line. Output pulse B (at T_2) is used as a variable time marker (intensity modulation of oscilloscope trace). The delay time is read directly off the T_2 dials. See figure 3-11.

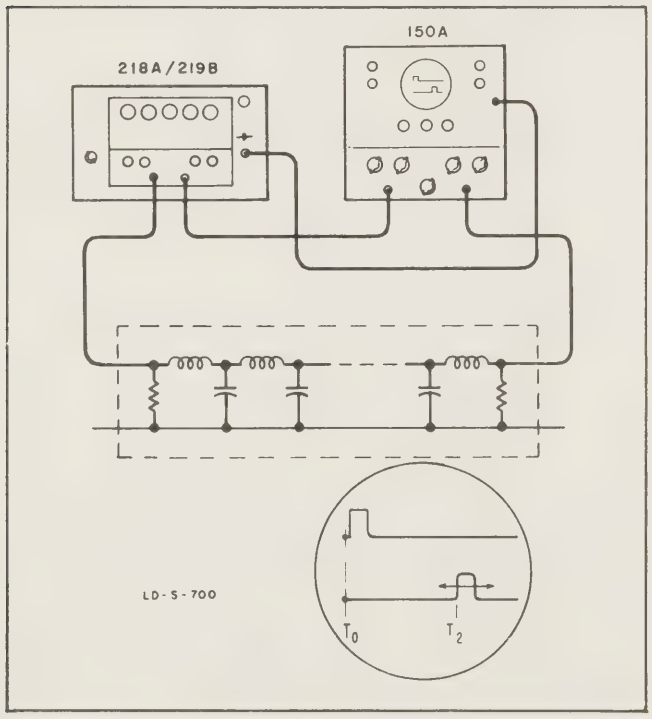


Figure 3-11. Measuring Time Delays

3-27. SWEEP TIME CALIBRATIONS: The horizontal sweep time can be calibrated by connecting the two outputs of the Model 219A unit to the vertical deflection of the oscilloscope. Synchronizing the oscilloscope with T_0, you will have T_1 and T_2 available as individual time markers. T_1 is adjusted so that its pulse appears at the end of the trace. The sweep time is read off the MICROSECOND DELAY dials of the Model 218A. See figure 3-12.

3-28. MEASURING SWEEP TIME LINEARITY: The sweep linearity can be measured by using the arrangement above which is similar to the sweep time calibration. Measuring a sweep time interval (e.g. 10% of full trace) at various points (beginning, center and end) will indicate the linearity of the oscilloscope sweep. The linearity of fast sweep traces (20 μsec or less) can be checked, by using the crystal-controlled 1 MC timing pulses available at the COUNTED FREQUENCY output jack.

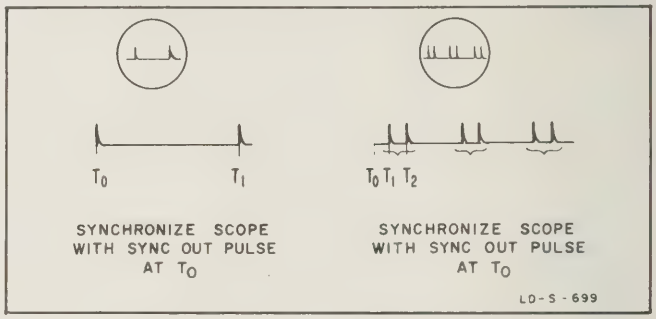


Figure 3-12. Sweep Time Calibration

3-29. RADAR SYSTEM CALIBRATION: Output pulse T_1 (and/or T_2) is used as a time marker. The radar scope is synchronized with the SYNC OUT pulse (T_0) of the Model 218A unit. For type B and PPI-system, introduce the precision time marks by intensity modulating the electron beam. In the case of the type A presentation, you can use the output of the Model 219C and feed it to the vertical input of the radar scope. See figure 3-13. The low output impedance of the plug-in pulse generators enables you to generate precise defined RF-pulses, occurring at T_0, T_1 or T_2. The RF-stages and IF-stages can be checked for gain bandwidth, etc.

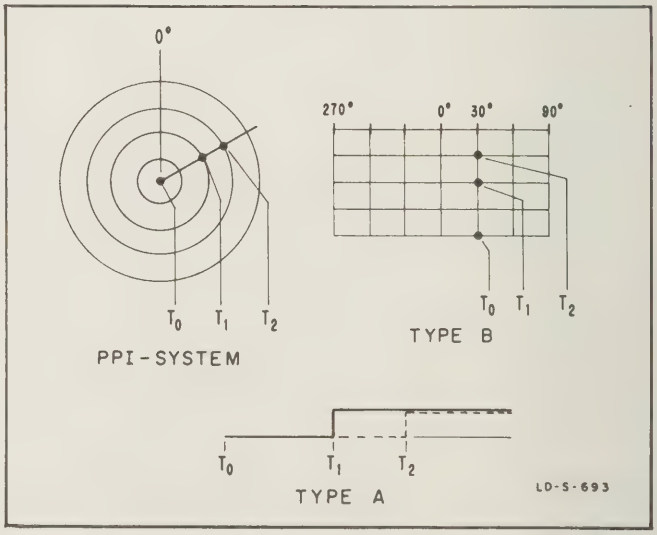


Figure 3-13. Radar System Calibration

3-30. JITTER MEASUREMENT: The Model 218A delivers a precision time delay after the occurrence of a random signal. If there is jitter in a periodic signal (i.e.: periodicity of the signal varies slightly

at random) it can be observed on the oscilloscope screen in the following way: Trigger the Model 218A externally with the signal, having jitter. Select time delay, so that it is slightly lower than the period of the signal to be measured. Synchronize oscilloscope with T_1 sync out pulse. See figure 3-14.

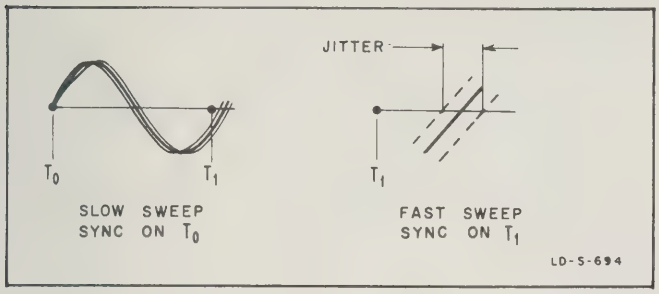


Figure 3-14. Jitter Measurement

3-31. DUAL PRESET COUNTER.

3-32. The versatility of the Model 218A is increased with the possibility of using an external time base to operate the counter of the instrument. The Model 218A can be operated with any one of its plug-in units as a preset counter.

3-33. A preset counter delivers an output signal after a predetermined number of events (pulses or cycles of sine waves) has occurred. The signal to be counted is fed to the EXT jack of the COUNTED FREQ. input. The start of the sampling period is obtained by triggering the Model 218A externally from the signal to be sampled. The end of the sampling period is given by output pulse T_1 or T_2. Since there are two individual delay (here sampling) channels, the Model 218A operates as a dual preset counter. See figure 3-15.

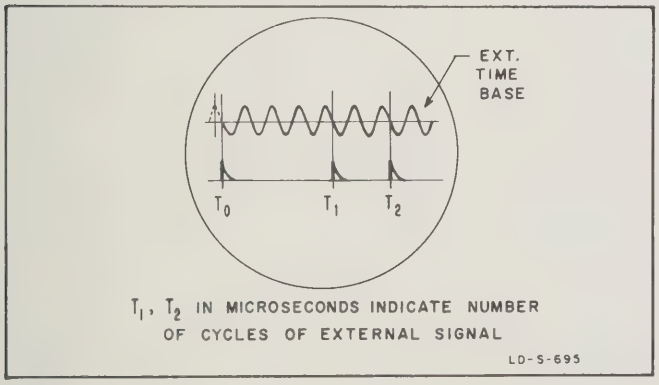


Figure 3-15. Preset Counter

3-34. There is a possible maximum one period jitter between T_0 and T_1 (or T_2) depending on the phase between the start trigger (internal or external) and the signal to be counted (external time base). Between T_1 and T_2 there is no jitter regardless of the phase and amplitude of the counted signal.

3-35. Using the Model 218A as a preset counter makes it possible to develop a simple system to monitor pulse cw systems, etc.

3-36. APPLICATIONS USING THE MODEL 219B OR MODEL 219C PLUG-IN UNITS.

3-37. With the two plug-in units, the Model 218A instrument becomes a multi-purpose pulse generator. Pulses can be synthesized to form gating pulses, step functions accurately timed by the delay unit of the Model 218A, etc.

3-38. Applications are measurements on pulse code systems, calibration of pulse multiplex systems. The resolution of gating circuits can be measured conveniently. Using the low driving impedance of the Model 219C plug-in generator, the ballistics of a meter movement can be calibrated by applying an accurately defined pulse. You can also measure the step function response of a mechanical recorder system. By applying an extremely short defined pulse, the transfer function of a 4 terminal network can be determined (filter, servo systems).

3-39. DEFINITION OF PULSE TERMS.

3-40. This paragraph contains a series of definitions of terms used in pulse measurements. Figure 3-16 shows a standardized pulse and the accompanying definitions describe the terms.

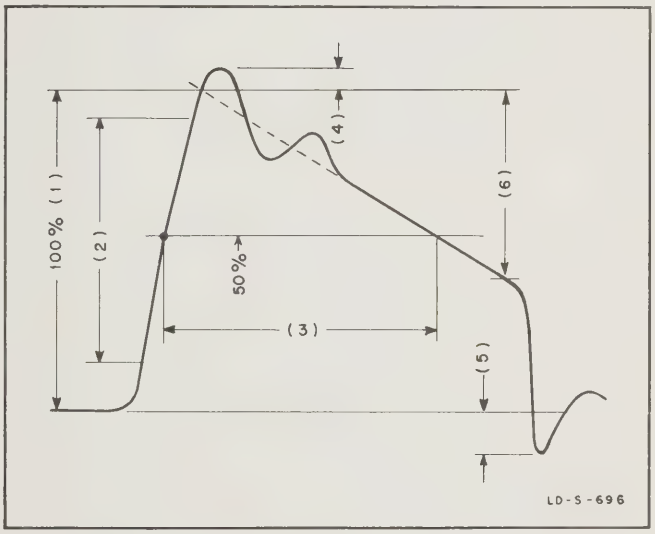


Figure 3-16. Standardized Pulse Definitions

a. Amplitude - Relative amplitude is defined in terms of the amplitude at the intersection of the leading edge of the pulse with a smooth curve approximating the top of the pulse, extended to meet the leading edge.

b. Rise Time - Time required for the pulse amplitude to increase from 10% to 90% amplitude.

c. Pulse Width - Duration in microseconds between the intersections of the 50% amplitude line with the leading and trailing edges of the pulse.

d. Overshoot - Amplitude of the first maximum excursion of the pulse beyond the 100% amplitude level expressed as a percentage of this 100% amplitude.

e. Backswing - Amplitude of the first maximum excursion in the negative amplitude direction after the trailing edge of the pulse, expressed as a percentage of the 100% amplitude.

f. Droop - The decrease in mean pulse amplitude from the 100% level, at some specified time interval following the initial attainment of 100% amplitude. This decrease is expressed as a percentage of the 100% amplitude.

3-41. PULSE CODE SYSTEMS. The Model 219B Dual Pulse Generator and the Model 219C Pulse Duration Unit can be used to synthesize gating pulses, step functions, etc, of extremely precise duration which can be used to make measurements on or calibrate pulse code systems or pulse multiplex systems. The resolution of gating circuits can be precisely measured.

3-42. METER MOVEMENT BALLISTICS TESTS. The Model 219C Pulse Duration Unit is ideal for determining meter movement ballistics characteristics. The low driving impedance together with the ability to supply a pulse of known duration makes it easy to apply the desired pulse and observe the ballistic characteristic response. Single pulses can be manually triggered when in the MANUAL TRIGGER mode.

3-43. MEASURING STEP-FUNCTION RESPONSE (Electrical or Mechanical). Apply an extremely short pulse from the Model 219C Pulse Duration Unit and observe the response.

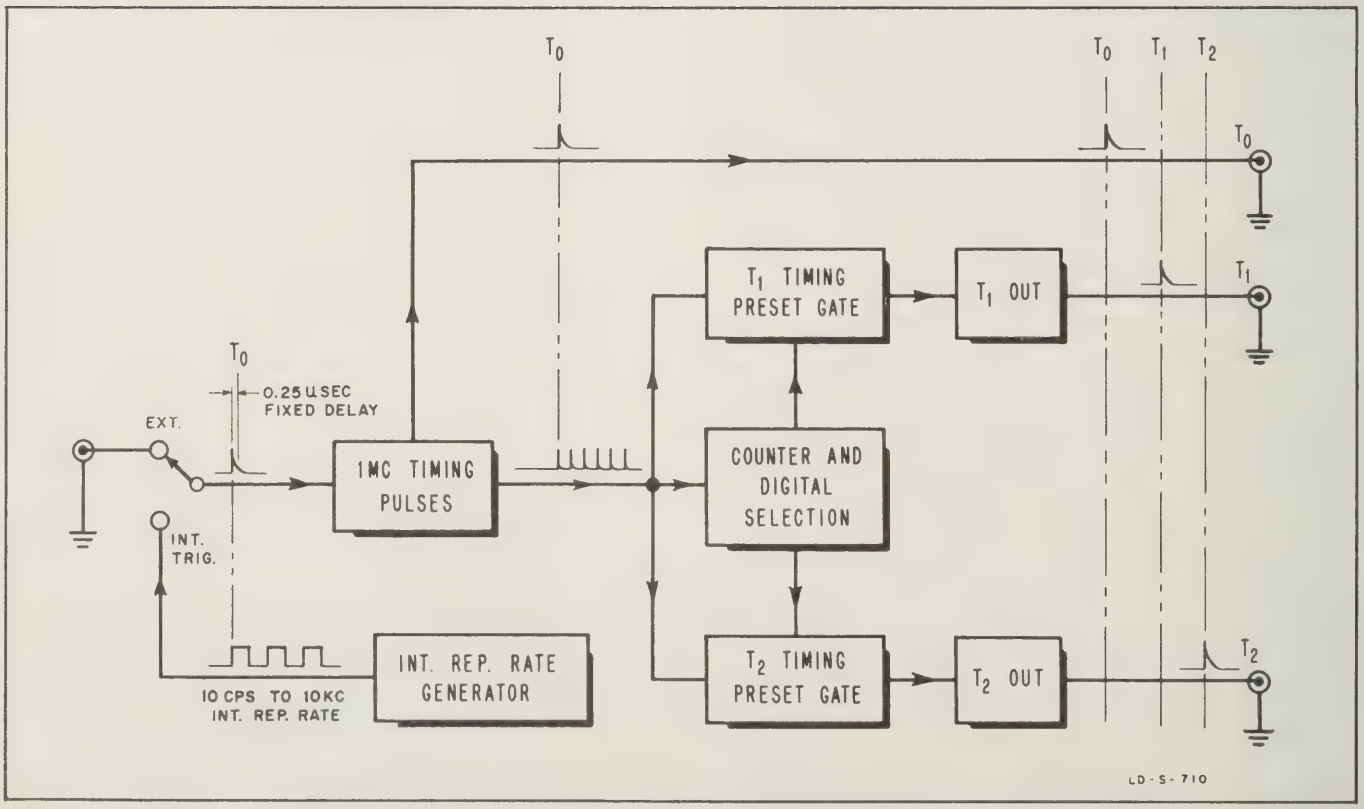


Figure 4-1. Simplified Block Diagram

SECTION IV
CIRCUIT DESCRIPTION

4-1. GENERAL.

4-2. This section describes the electrical operation of the circuits. First the over-all operation of the instrument is described, with reference to a simplified block diagram (see figure 4-1). Paragraph 4-9 describes the complete block diagram, covering the important circuit sections. A detailed description of the circuits follows in paragraphs 4-28 through 4-96.

4-3. OVER-ALL OPERATION.

4-4. To facilitate the understanding of the operation principle, the interpolation multivibrator will be temporarily disregarded.

4-5. A trigger pulse (external or internal) starts a time delay period. A sequence of 1-mc timing pulses is generated time locked with the trigger signal. The accuracy of the timing pulses is determined by a crystal-controlled oscillator (better than ±0.001%).

4-6. The 1-mc pulses are counted in a four-decade counter. When the number of 1-mc pulses has reached the value preselected by the MICROSECOND DELAY dials a trigger voltage is generated. The trigger voltage controls the suppressor grid of preset gate T_1 (or T_2). See figure 4-2.

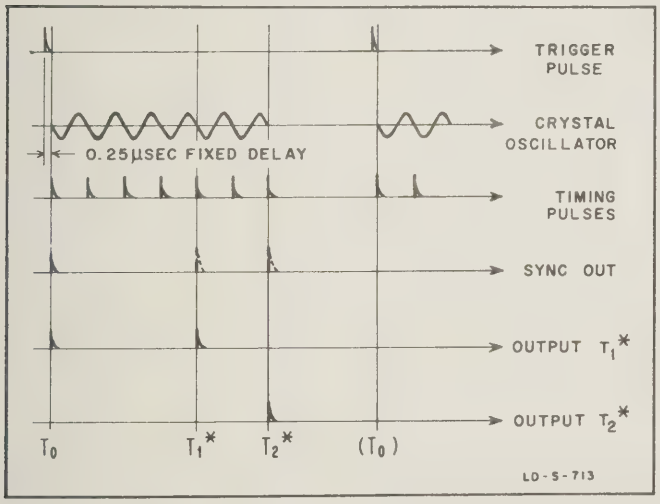


Figure 4-2. Internal Time Base

4-7. The 1-mc timing pulse following immediately after the gate has opened will pass through the gate and determine the end of a delay period (T_1* or T_2*). The accuracy of the delay period is not affected by jitter introduced in the pulse and counter circuits. Figure 4-3 shows the time relationship between the timing pulse and the trigger voltage on the suppressor grid of the preset gate.

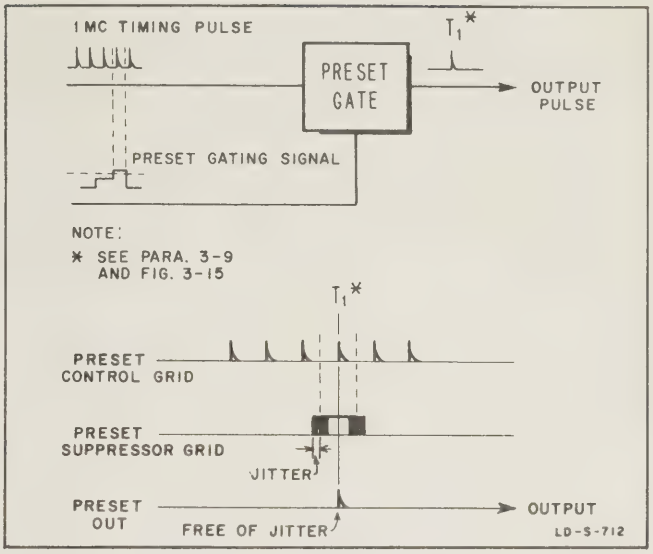


Figure 4-3. Output Pulse

4-8. At the end of the longer delay period (T_1 or T_2) the timing pulses are stopped and the decades reset. A period of approximately 50 μsec is added to allow the quartz crystal to come to a complete stop. At this moment the Model 218A is ready to be triggered for the next delay period.

4-9. COMPLETE BLOCK DIAGRAM.

4-10. Figure 4-4 shows the complete block diagram of the instrument. The basic wave shapes of figure 4-5 are keyed to the complete block diagram. Not included are the plug-in units at the output.

4-11. INPUT AMPL./RATE GENERATOR. Provides trigger pulses (internal or external) of maximum 10 kc repetition rate to initiate delay periods.

4-12. LOCKOUT GATE. Prevents retriggering of delay circuits until 50 μsec after longer delay period has elapsed (crystal recovery).

4-13. GATE CONTROL BINARY. Supplies gating pulse to crystal oscillator, 1 MC Ringer and timing pulse gate, start: T_0; stop: at the end of T_2 (longer delay); controls the LOCKOUT GATE.

4-14. CRYSTAL START STOP GATE. Controls crystal oscillator, starts crystal oscillator in correct phase approximately 1/2 μsec after T_0; stop: at T_2.

4-15. 1 MC CRYSTAL BRIDGE. Balanced crystal oscillator, excited through trifilar-wound transformer by crystal start-stop gate.

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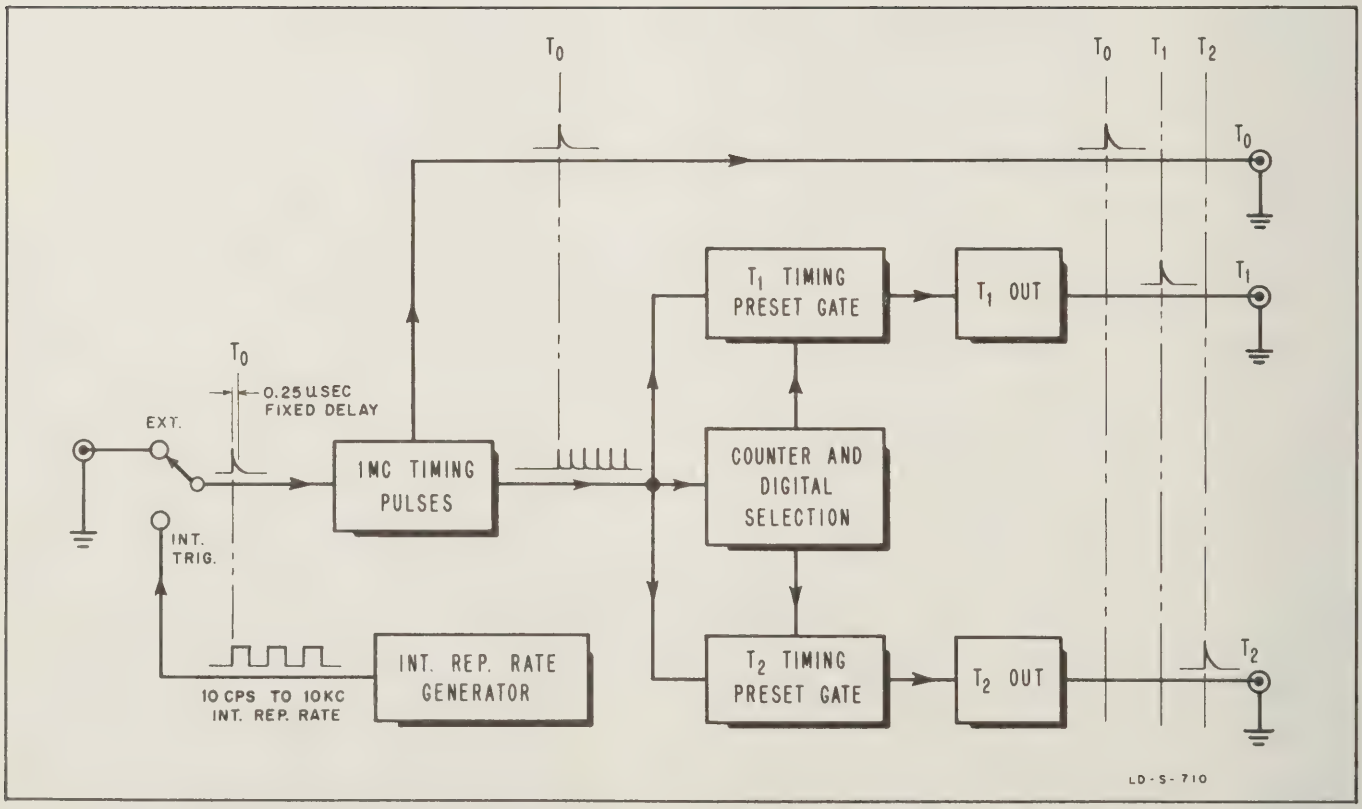


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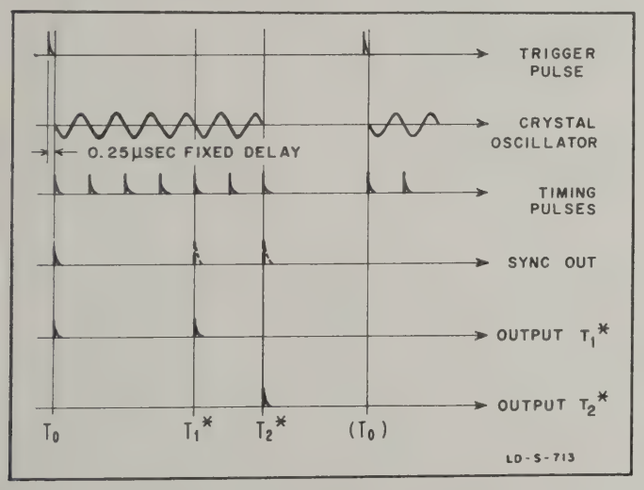


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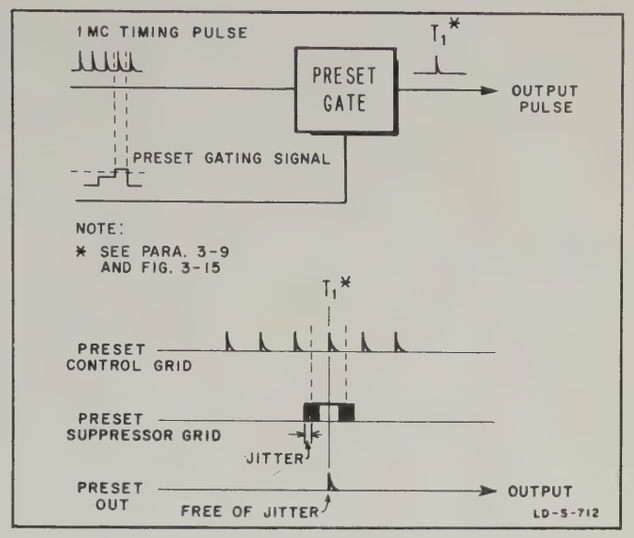


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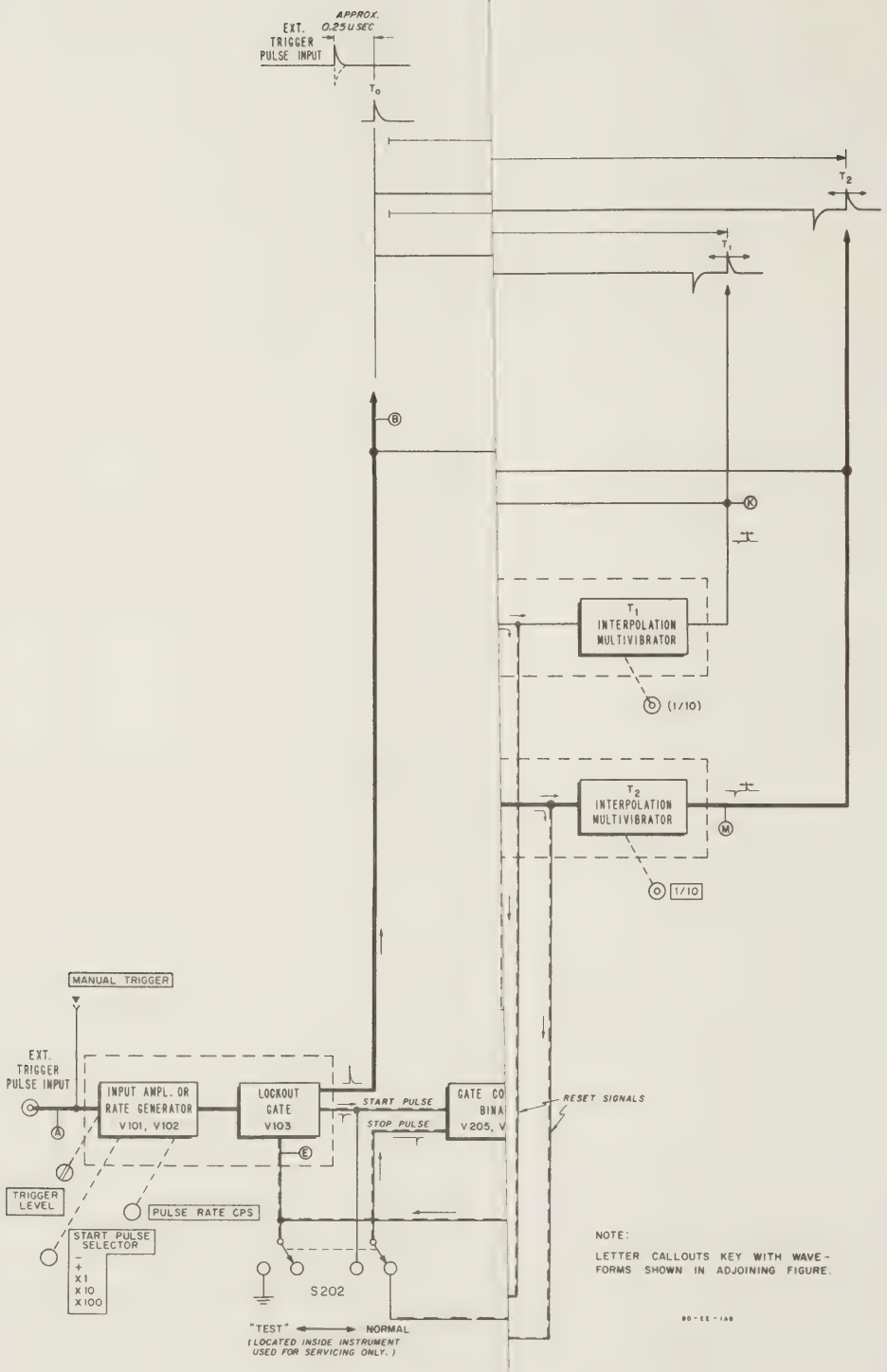


Figure 4-4. Complete Block Diagram

4-18. 1 MC RINGER. Gated by gate binary, supplies first several cycles of 1 mc signal to timing circuits (crystal signal linearly added).

4-19. AMPLIFIER AND SCHMITT TRIGGER. Amplifies the 1 mc time base signal from crystal oscillator and ringer, forms timing pulses.

4-20. TIMING PULSE GATE. Controlled by gate binary, supplies 1 mc timing pulses starting at T_0, ending at T_2 (longer delay period).

4-21. DIGITAL COUNTER, TIMING CIRCUIT. Counts 1 mc timing pulses, supplies control signal to preset gates, at T_1 and at T_2 respectively.

4-22. PRESET GATE T_1 (T_2). Opens at time T_1 (T_2 respectively) to pass correct timing pulse from crystal oscillator to trigger interpolation multivibrator.

4-23. INTERPOLATION MULTIVIBRATOR. Adds 1 μsec minimum delay time. Continuously adjusted to 2 μsec maximum (counter resets to 0001.0 to compensate).

4-24. RESET DISCRIMINATOR. Provides trigger pulse to reset blocking oscillator after T_1 and T_2 have elapsed.

4-25. RESET BLOCKING OSCILLATOR. Reset Counter Gate Binary and Reset Discriminator.

4-26. RELAXATION OSCILLATOR. Triggers reset blocking oscillator, in case one of the 4 beam-switching tubes is not operating properly.

4-27. BLOCKING OSCILLATOR. Supplies a high powered trigger pulse for SYNC OUTPUT, selectable to coincide with T_0, T_1 or T_2.

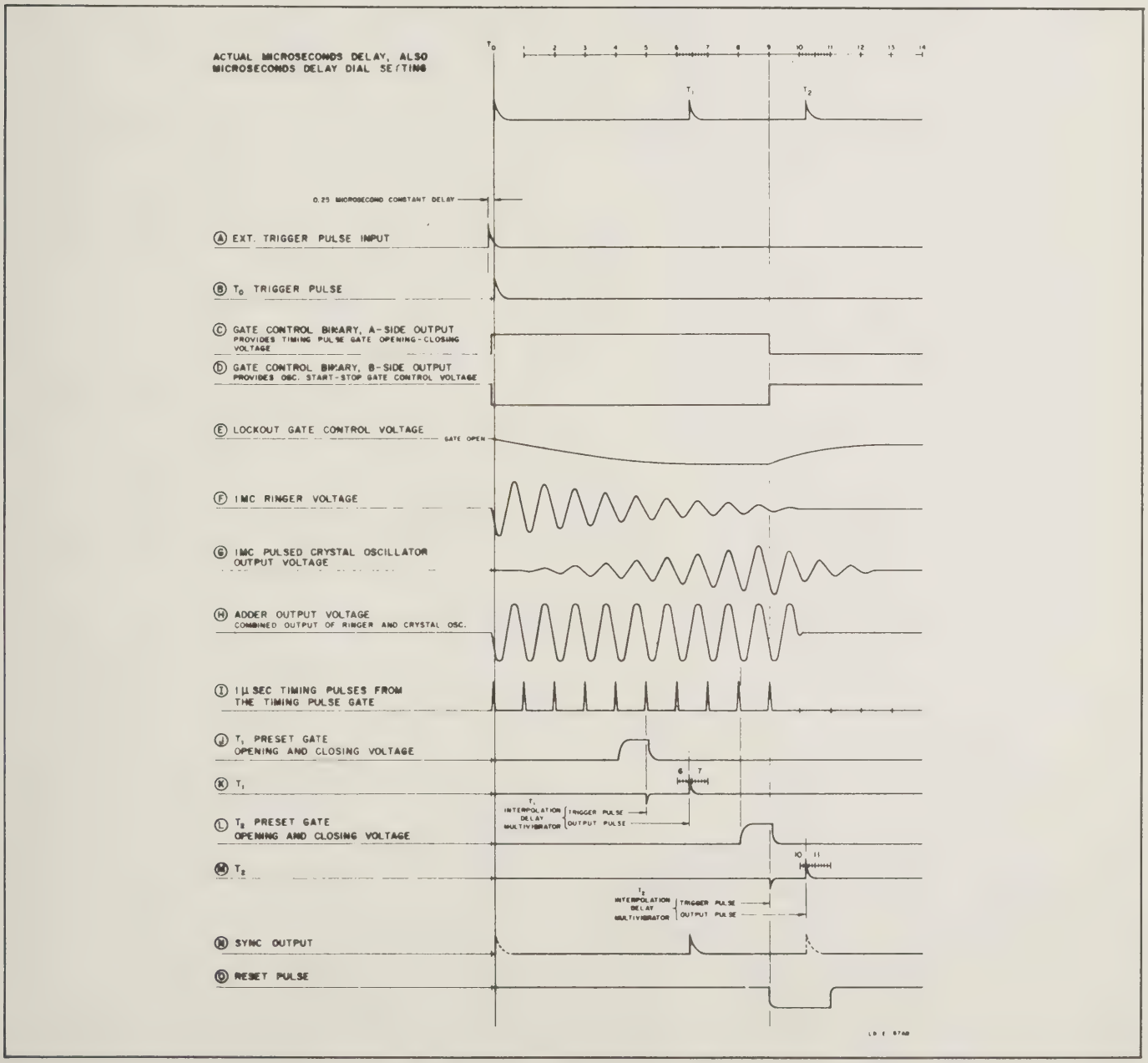


Figure 4-5. Basic Wave Shapes and Timing Sequence

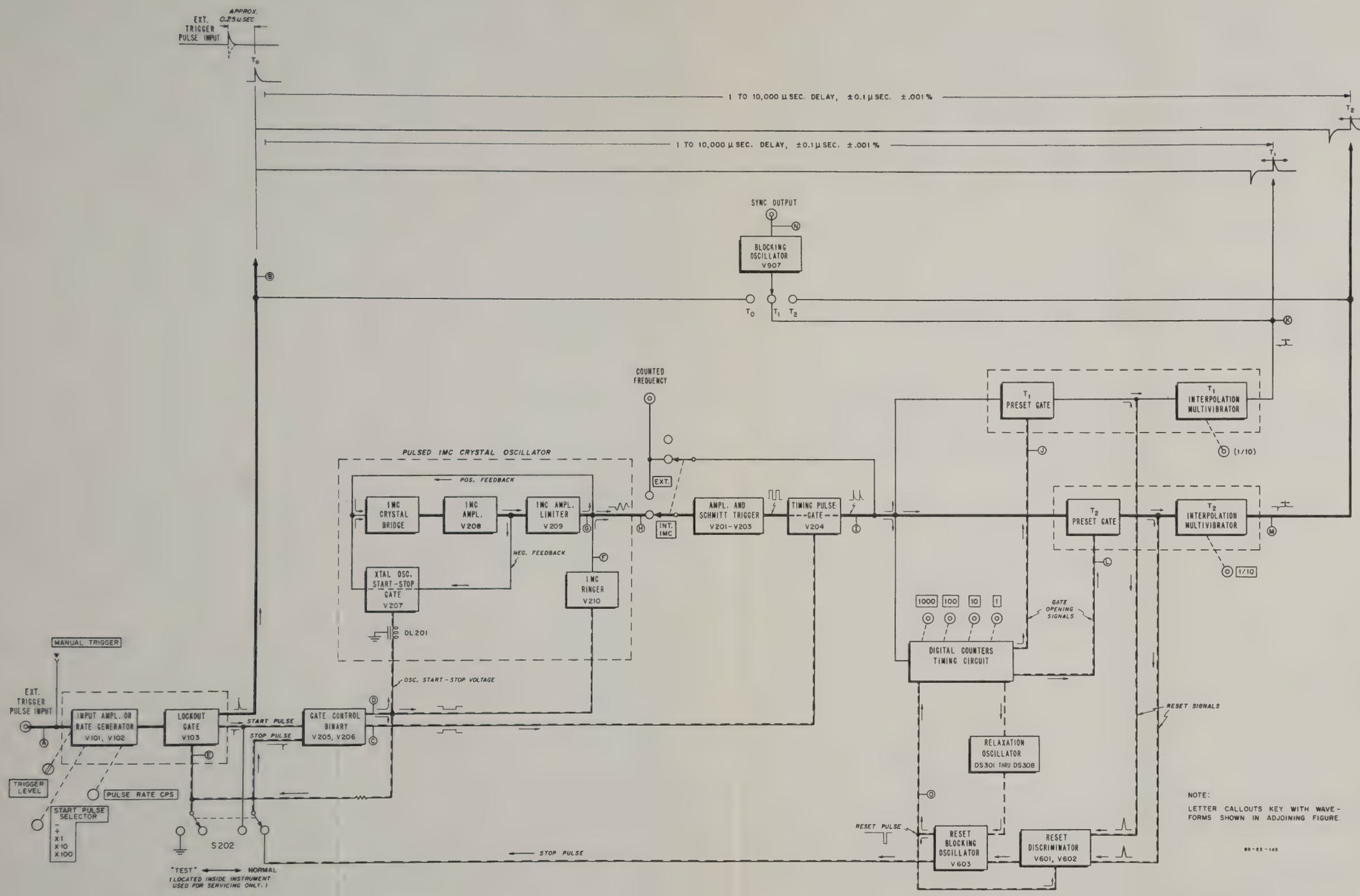


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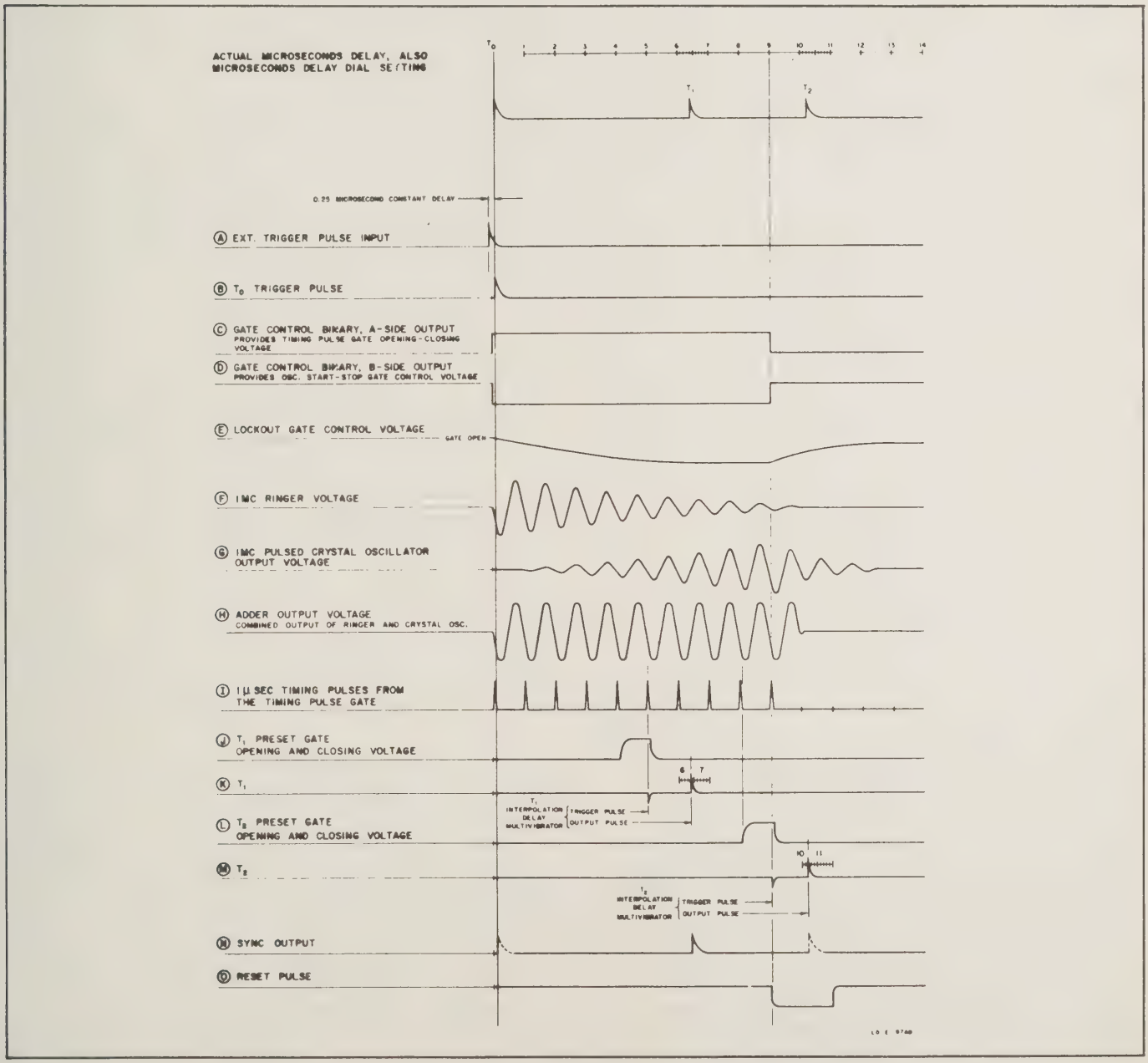


Figure 4-5. Basic Wave Shapes and Timing Sequence

4-28. INPUT CIRCUIT, INT. RATE GENERATOR AND LOCKOUT GATE.

4-29. This circuit provides a standardized, positive trigger pulse to operate the lockout gate, when excited by a trigger signal at the INPUT. The trigger signal is received either through external trigger input (see figure 4-6) or internally from an internal repetition rate generator (see figure 4-7). In addition single delay periods can be initiated by depressing the MANUAL TRIGGER push button.

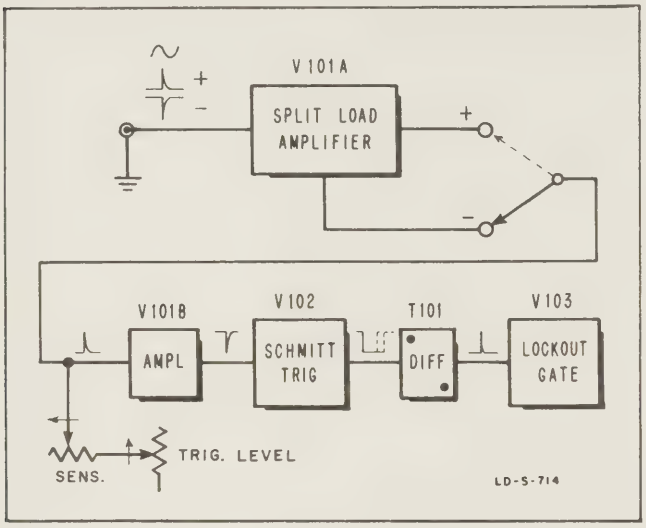


Figure 4-6. Input Block Diagram on External Trigger

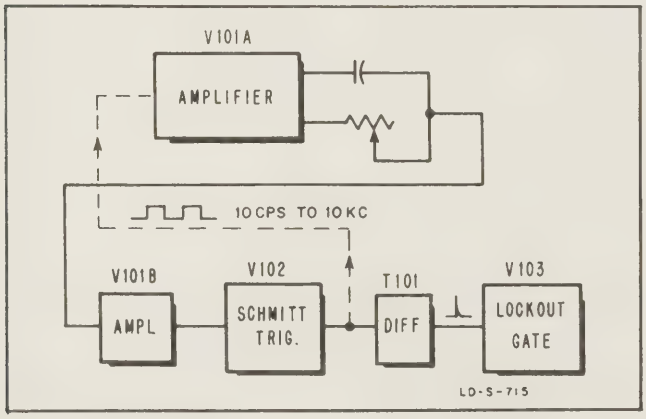


Figure 4-7. Input Block Diagram on Internal Pulse Rate

4-30. The external trigger pulse is amplified in V101A, which operates as a split-load amplifier. The START PULSE SELECTOR switches a positive going pulse to the control grid of V101B. The dc-bias circuit of this stage, incorporates the external sync. sensitivity, the TRIGGER LEVEL control and the MANUAL TRIGGER SWITCH for single pulse operation. The output pulse of V101B is fed to a Schmitt trigger V102, which produces a negative-going pulse with a sharp leading edge. The pulse is differentiated in T101, inverted and fed to the control grid of the lockout gate V103.

4-31. When the START PULSE SELECTOR switch is in position X1, X10 or X100, stages V101A, V101B and V102 are connected for self oscillation, delivering a square wave at pin 1 of V102A. The negative swing of the square wave is differentiated, inverted and provides the trigger pulse for the control grid of the Lockout Gate.

4-32. FREE-RUNNING RELAXATION OSCILLATOR.

4-33. The oscillator combines a two-stage amplifier with a Schmitt trigger in cascade (see figure 4-8). The two "half periods" of the oscillation are controlled by a single rc-network, coupling the plate and cathode of the first amplifier to the control grid of the second amplifier. Feedback is employed from plate V101B through V102, to the grid of V101A to obtain the desired free-running condition.

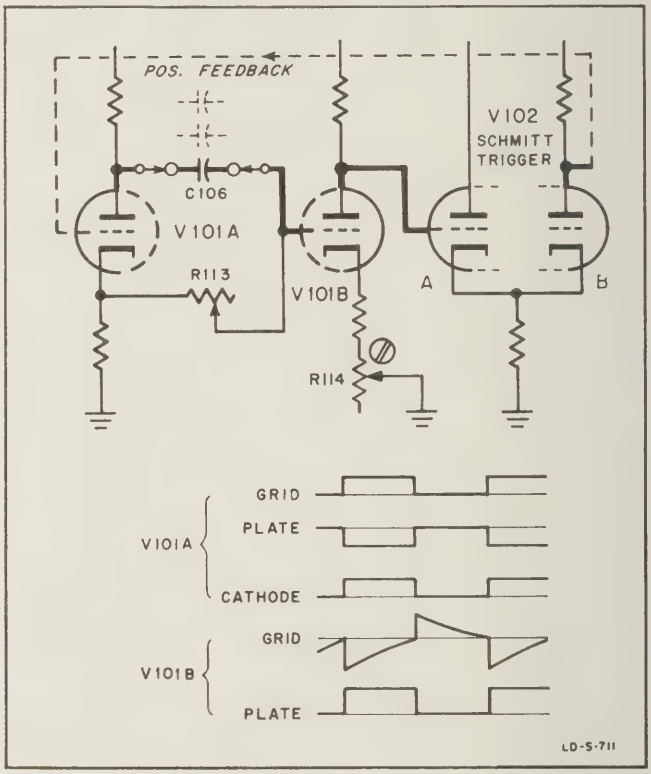


Figure 4-8. Internal Rate Generator

4-34. Assume a positive transient drives the first amplifier V101A into conduction. The negative signal appearing at the plate is coupled through the capacitor C106 to the control grid of the second amplifier V101B, driving this stage toward cutoff. The positive signal at the plate of V101B is coupled through the Schmitt trigger V102 (no inversion) and applied to the grid V101A as a positive feedback. V101A will go to saturation, the capacitor C106 will discharge through R113 at a rate determined by its rc time. When C106 has discharged sufficiently, V101B will go back into conduction. It will remain in conduction until V101A goes into cutoff and C106 again starts discharging through R113, thus completing one full cycle. The frequency of the square wave is controlled by the capacitor C106 through C108 (Decades) and resistor

R113 (Variable, interpolation within one decade). R114 (Internal Square Wave Symmetry) set the cut-off point of V102A. Thus proper symmetry can be attained.

4-35. LOCKOUT GATE.

4-36. The lockout gate prevents the start of a new delay period until 50 μsec after the termination of the longer delay period (T_1 or T_2). The 50 μsec are necessary to allow the crystal to come to a complete rest after it has been stopped at the end of the longer delay period.

4-37. A gating pulse from the gate binary V206 is applied to the suppressor grid of the lockout gate V103. An rc network (R238 and C239) in the suppressor grid circuit provides a 50 μsec delay of the gating pulse.

4-38. The lockout gate provides a trigger pulse T_0 as a time reference for the delay time periods.

4-39. GATE BINARY CIRCUIT.

4-40. CIRCUIT FUNCTION.

4-41. Start the 1-mc ringer to start the 1-mc crystal oscillator, to open the 1-mc timing pulse gate, and to close the lockout gate for the duration of the longer delay period (T_1 or T_2) +50 μsec. (50 μsec necessary for reset and recovery of crystal.) See figure 4-9.

4-42. DESCRIPTION OF THE CIRCUIT.

4-43. The gate binary V206 is a bistable multivibrator. A negative-going pulse on control grid (7) of V206 initiates the first phase. Plate (6) of V206 rises, C207 provides positive feedback to control grid (2). The second phase is started by a negative trigger pulse from the reset circuit applied to control grid (2) of V206. Plate (1) rises, C209 providing positive feedback to control grid (7).

4-44. The timing pulse gate is operated through cathode follower V205A. A negative-going gating pulse starts the 1 mc ringer stage. After a delay of 1/2 μsec the crystal start-stop gate V207 is started operating by a negative gating pulse on its suppressor grid. The negative gating pulse of cathode (3) of V205 also closes the lockout gate V103.

4-45. PULSED CRYSTAL OSCILLATOR.

4-46. This section provides a 1-mc signal, which is crystal controlled and phase locked with the trigger pulse T_0.

4-47. In order to maintain an over-all accuracy of ±.1 μsec for a delay period up to 10,000 μsec with respect to a random external trigger pulse, it is important to establish a precise phase relationship between the 1-mc oscillation and the initiating trigger pulse. The phase of the first few cycles of a pulsed crystal oscillator is not sufficiently accurate to be used for timing purposes. This is due to a possible unbalance of the oscillator bridge.

4-48. An LC-ringing circuit, on the other hand, behaves in a predictable manner when excited by a voltage transient.

4-49. For this reason the oscillations of a pulsed 1-mc ringing circuit are added on the oscillations of the crystal. See figure 4-5 and figure 4-10.

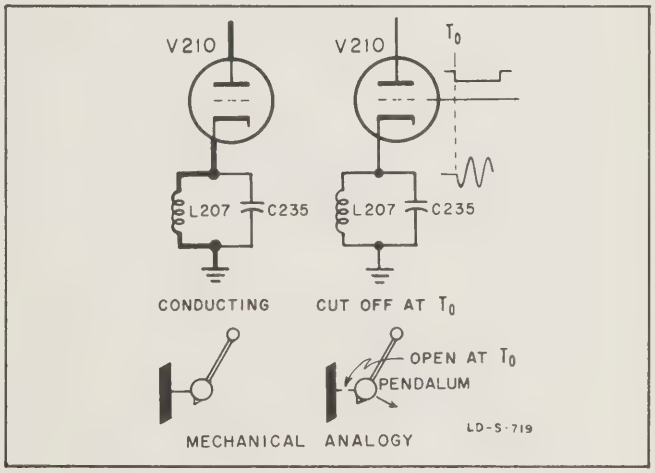


Figure 4-10. 1-Mc Ringer

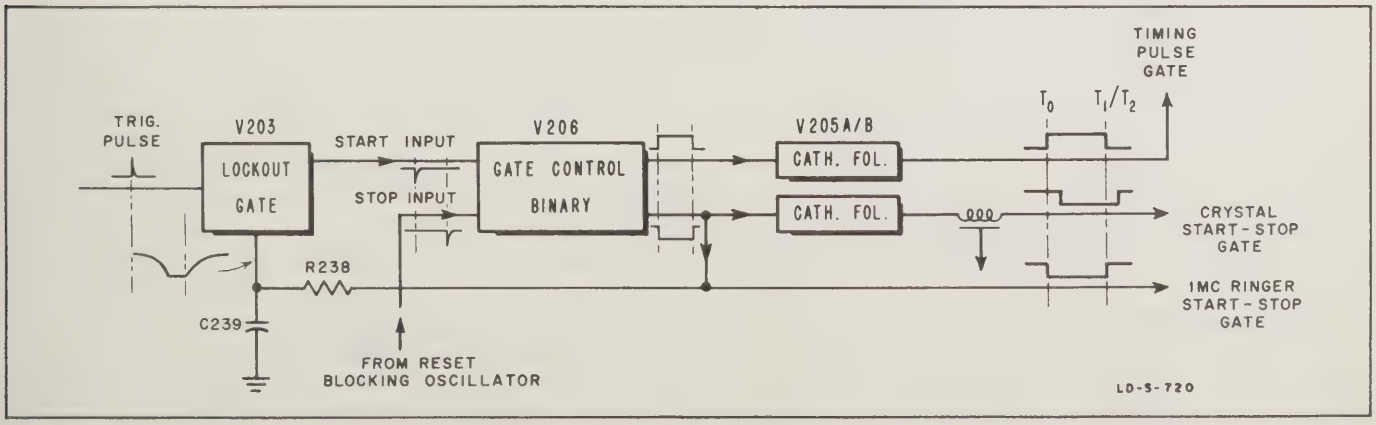


Figure 4-9. Gate Control Binary

4-50. 1-MC RINGING CIRCUIT.

4-51. A negative-going gating pulse at control grid (7) of V210 drives this tube into cutoff. The stored energy in L207 starts oscillating with its associated capacities at 1 mc, phase locked with the leading edge of the gating pulse. (See pendulum analogy figure 4-10.) The 1-mc signal is fed to the first amplifier V201 of the timing pulse circuit.

4-52. CRYSTAL OSCILLATOR CIRCUIT.

4-53. One-half a microsecond after the 1-mc ringer has been gated for oscillation, stage V207 is cut off by its suppressor grid. Plate (5) of this stage rises sharply, producing a positive voltage transient in winding A of L204. After phase reversal, coils B and C energize the bridge and excite the crystal to oscillate in its shunt mode frequency. If the bridge is properly balanced the transient does not appear at the output but excites the crystal at a known phase. The slow build up of the oscillations, even with the bridge perfectly balanced is due to the high Q of the crystal. The output signal of the crystal is amplified in V208 and limited in V209. (See figure 4-11.)

4-54. Capacitor C213 provides positive feedback from plate (5) of V209 to the bridge. The two tank circuits of the oscillator bridge are tuned slightly below 1 mc. The crystal-controlled 1-mc signal is added to the 1-mc ringer signal and fed to the control grid (6) of V201. At the end of the delay period a positive transient on the suppressor grid (7) of V207 drives this stage into conduction. Two events take place:

a. The voltage drop at plate (5) of V207 is timed to be 180° out of phase with the voltage swing of the bridge. The result is, that the voltage transient coupled through L204 into the bridge will cancel most of the energy of the quartz crystal.

b. Negative feedback from plate (5) of V208 is applied to control grid of V207.

4-55. After the crystal stop pulse brought the quartz crystal to a stop rapidly an additional delay period of approximately 50 μsec is added for the complete stopping of the crystal (dissipation of residual energy). At this time the circuits are ready for the next trigger pulse starting a new delay period. The crystal is now in a quiescent stage again ready to start an oscillation at random time.

4-56. TIMING PULSE CIRCUITS.

4-57. These circuits provide accurately spaced, jitter-free 1-mc timing pulses during the gating time determined by the setting of T_1 or T_2, whichever is greater. (See figure 4-12.)

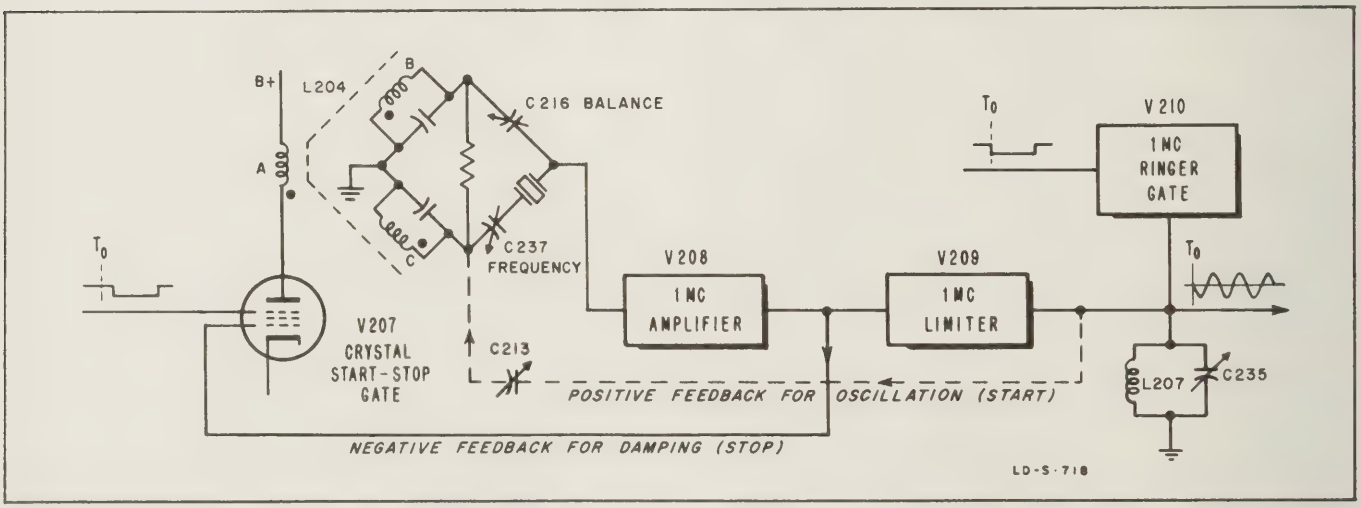


Figure 4-11. Pulsed Crystal Oscillator

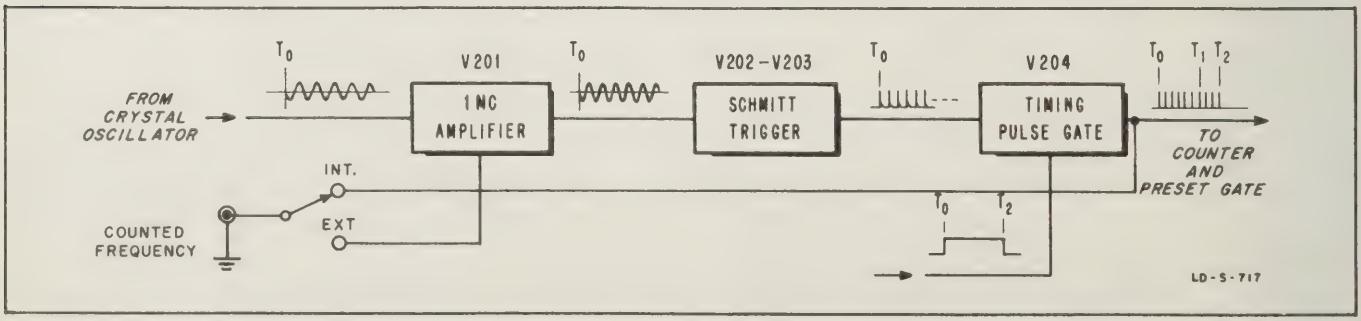


Figure 4-12. Timing Pulse Circuits

Note

Pulse inverters (transformers or inverter tube stages) are used throughout the different pulse circuits to drive pulse amplifiers with a positive pulse. The output pulse of an amplifier driven by a positive pulse has better rise time characteristics than when driven by a negative pulse.

4-58. MODES OF OPERATION.

4-59. There are two operation modes:

a. Internal 1 mc - The 1-mc signal from the pulsed crystal oscillator circuit is amplified and fed to the Schmitt trigger V202 and V203. 1-mc timing pulses appear at the output of the Schmitt trigger. The first pulse occurs at T_0.

b. External Counted Frequency - Instead of the internal 1 mc signal, sine waves from 10 cps to 1 mc, or pulses of maximum 1-mc repetition rate may supply the time base signal. The time delay, set with the MICROSECOND DELAY dials, is then expressed in numbers of periods of the applied external time base (see paragraph 3-21).

4-60. TIMING PULSE GATE.

4-61. The output of the timing pulse gate provides a train of 1-mc pulses for the duration of the longer delay period (T_1 or T_2). A positive gating pulse from the gate control binary is applied to the suppressor grid of V204. The 1-mc timing pulses fed to the control grid of V204 appear at its plate, as long as the gating pulse keeps V204 conducting.

4-62. COUNTER AND DIGITAL PRESELECTION CIRCUIT.

4-63. The purpose of the counter and preselection circuit is to:

a. Count the 1-mc timing pulses (up to 10,000 pulses for a maximum delay of 10,000 μsec).

b. Provide a trigger voltage, when the number of timing pulses coincides with the number of microseconds preselected on the four digital MICROSECOND DELAY dials. The timing pulse following the one that opened the preset gate will determine the selected delayed time.

4-64. BEAM SWITCHING TUBE.

4-65. The heart of the digital counter is a type 6700 Magnetron Beam switching tube (see figure 4-13). This tube has ten targets (plates from which output is taken), ten spades (electrodes for forming and locking of electron beam) and ten grids (electrode for forming and advancing of the electron beam) coaxially located around a common cathode.

4-66. The whole assembly is mounted within a permanent magnet to obtain an axial magnetic field. Electrons leaving the cathode will observe a deflection force due to the simultaneous presence of a transverse electrical field and an axial magnetic field. Switching of the electron beam by negative trigger pulses results in an unidirectional advancing of the beam from one target (e.g. 1) to the next target (i.e. 2). Having reached target (9), the beam advances to target (0).

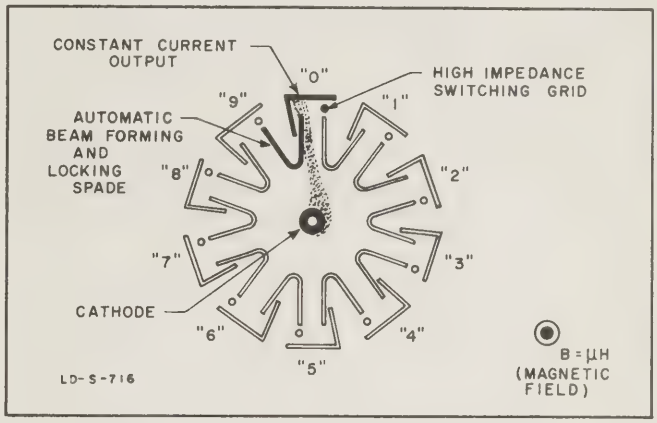


Figure 4-13. Beam Switching Tube

4-67. Resetting of the decades consists of two operations:

a. A 200-volt negative-going pulse from the reset blocking oscillator clears the tube (extinguishing the electron beam) by dropping the spade voltage to the cathode potential.

b. At the end of the reset pulse, the spade voltages return to normal at a rate depending on the rc-time constant of the spade circuits. The time constant of one spade circuit is purposely made longer, so the beam reforms on this position. The "Units" decade is reset to "1", see paragraph 4-74 all others are reset to "0".

c. A preset gate "gates out" the timing pulse following the one which caused it to open, so it would appear that the delay would be 1 microsecond greater than indicated by the dial settings. This is taken care of by designing the timing pulse generator to put out a timing pulse at zero time as well as at each microsecond thereafter.

4-68. COUNTING OF THE 1-MC TIMING PULSES.

4-69. Since time base pulse T_0 appears as the first pulse of the pulse sequence, it will advance the "Units" decade by one position. At the end of 1 μsec the next pulse will advance the beam to position two etc. The four decades are driven in parallel by the timing pulses. The gate pulse concidence circuit unlocks the control gates of the TEN, HUNDRED, and THOUSAND decades at the correct time.

4-70. 9-99-999 GATE COINCIDENCE CIRCUIT. This circuit opens the control gates, (i.e. the 9-gate, 99-gate and 999-gate) only when specific conditions are fulfilled, so that the next timing pulse advances the beam of the gated decade by one position. A passive resistor network adds the gating pulses according to their relative weight:

9-Gate opens only when unit decade on "9".

99-Gate opens only when unit and tens decade are on "9" simultaneously.

999-Gate opens only when unit, tens and hundreds decades are on "9" simultaneously.

4-71. PRESET GATE COINCIDENCE CIRCUIT. The preset gate circuit is similar to the 9-99-999 gate circuits. A trigger signal is produced, when the electron beams of the four decades simultaneously reach the position as determined on the four MICROSECOND DELAY selector switches.

4-72. There are two identical Preset Gate Sections (T_1 and T_2). The following description refers to Preset Gate Section T_1 only (see figure 4-14).

4-73. The sample target voltages are added and fed to the suppressor grid of the preset gate. Assume a preselected delay period of 5555 μsec. Since the first timing pulse occurs at T_0 the timing pulse occurring 5554 μsec after T_0 advances the four decades to position 5555. The preselection coincidence circuit opens preset gate T_1. The next timing pulse (i.e. 5555 μsec) passes through the preset gate and triggers the interpolation multivibrator. The same timing pulse which closes the preset gate advances the decades to position 5556. The counter continues to count the 1-mc timing pulses until the end of the second longer delay period.

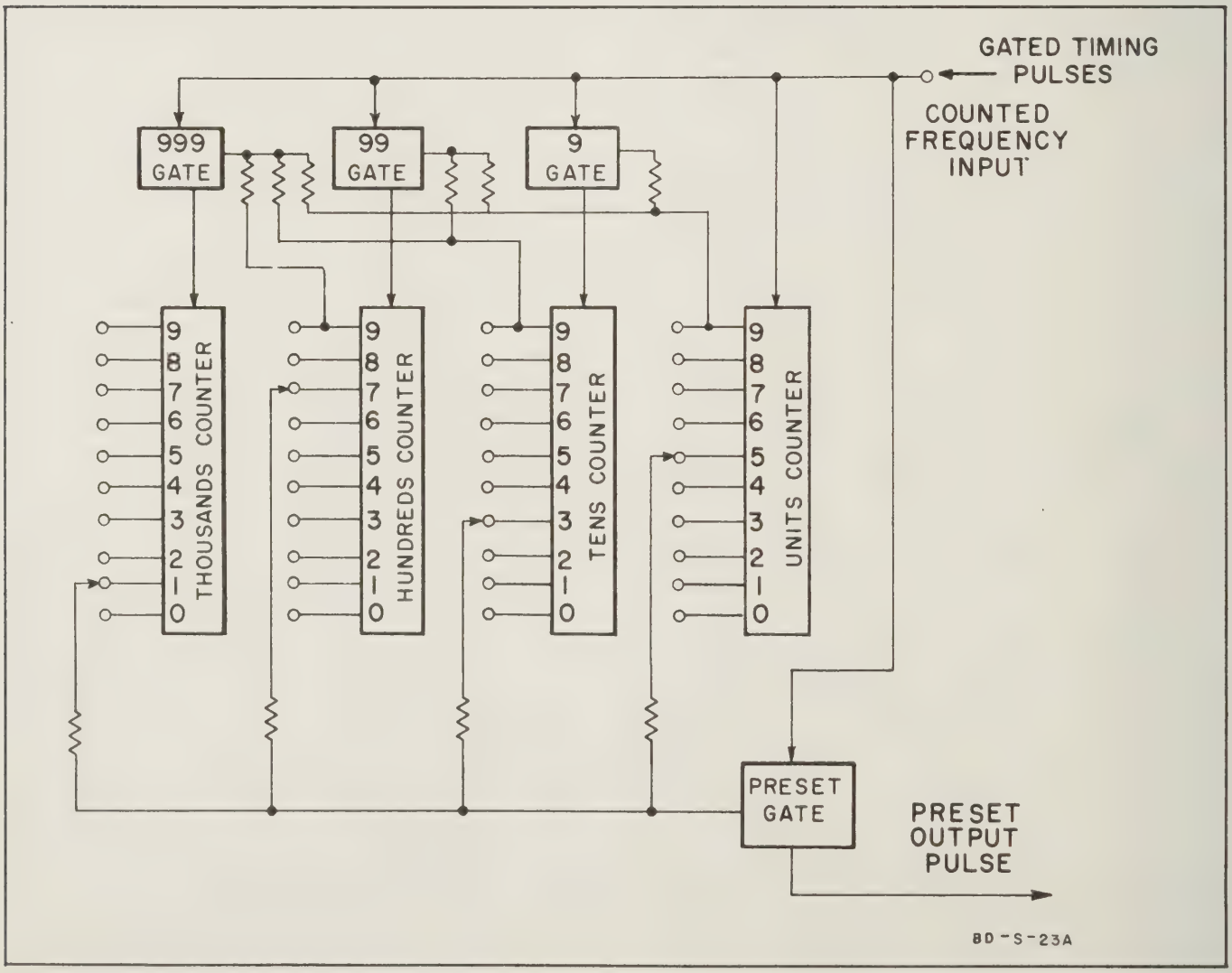


Figure 4-14. Counter Block Diagram

4-74. INTERPOLATION DELAY MULTIVIBRATOR.

4-75. There are two identical Interpolation Delay Multivibrators (V502 and V504) following the Preset Gates, one for the T_1 output and one for the T_2 output (see figure 4-15). The interpolation multivibrators are one-shot multivibrators which provide an additional delay adjustable over a one microsecond range to provide interpolation, calibrated in tenths of microseconds, between the microseconds steps selected by the digital counters. The Interpolation Delay Multivibrator running time is approximately 1 μsec at 0 on the 1/10 dial, and 2 μsec at 10 on the 1/10 dial. Since the minimum delay multivibrator running time is approximately one microsecond (with the 1/10 dial set to "0") it will not put out a trigger pulse until 1 μsec after receiving a timing pulse from its associated preset gate. To correct for this extra one microsecond delay the counter is reset to 0001 instead of 0000.

4-76. With the understanding of the interpolation multivibrator we look again at the example of paragraph 5-60. Timing pulse ("5555") passing through preset gate triggers the plug-in unit 5556 μsec after T_0. Resetting the decades to "0001" means that timewise all events take place one microsecond earlier. For a preselected delay time of 5555 μsec preset gate opens at 5553 μsec and the interpolation multivibrator is triggered 5554 μsec after T_0. The interpolation multivibrator triggers the plug-in units 5555 μsec after T_0.

4-77. RESET CIRCUITS.

4-78. At the end of the longer delay period (T_1 or T_2) the reset blocking oscillator supplies a reset signal.

4-79. The Reset Pulse resets the Binary, the Decade Counters, and the Reset Discriminator. The Gate Binary simultaneously closes the Timing Pulse Gate, clamps the 1-mc Ringer Stage, stops the Crystal Oscillator (after 1/2 μsec), and opens the Lockout Gate (after 50 μsec). In order to get a clear picture of the reset phase, as shown in figure 4-16, the relaxation oscillator is temporarily disregarded. Its function can be discussed separately and will be described in paragraph 4-84.

4-80. RESET DISCRIMINATOR.

4-81. The reset discriminator triggers the reset blocking oscillator only when the reset pulses from both preset gates (T_1 and T_2) have occurred.

4-82. During the delay period, triodes (pins 1, 2, 3) of V601 and V602 are cut off. At the same time triodes (pins 6, 7, 8) of both tubes are conducting. The plates (pin 6) of both tubes are clamped to ground through CR601. Reset pulses T_1 and T_2 cut off the corresponding triode sections of V601 and V602. The junction of C612 and R617 rises sufficiently to trigger grid (pin 2) of the reset blocking oscillator V603. The rise of grid (pin 2) V603 is determined by the time constant of the associated rc-network and the dc-bias. R627 adjusts the trigger time phasing of V603 with respect to the 1-mc timing pulses. Thus the timing of the reset pulse can be adjusted for maximum damping of the crystal oscillator oscillations.

4-83. The discriminator circuits are reset to their original condition by the sharp rise coupled to their grid circuits through C614 and C615 at the end of the reset pulse.

4-84. RELAXATION OSCILLATOR.

4-85. If the electron beam does not form in one of the type 6700 decade tubes, the Reset Blocking Oscillator will be triggered by a relaxation oscillator (see figure 4-17). The relaxation oscillator always operates when the instrument is turned on.

4-86. The result of the absence of an electron beam is that the reset pulse of the following delay period cannot be generated. If the reset pulse does not occur, the Model 218A is disabled completely.

4-87. At this moment the relaxation oscillator triggers the reset blocking oscillator, thus generating a reset pulse and unlocking the circuits.

4-88. The electron beam current is sampled across a common resistor (R344 for the "Units" decade). Indicator lamp DS304 (for "Units" decade) will light, as long as the beam is formed. With no beam formed in the "units" decade, a relaxation oscillation is started:

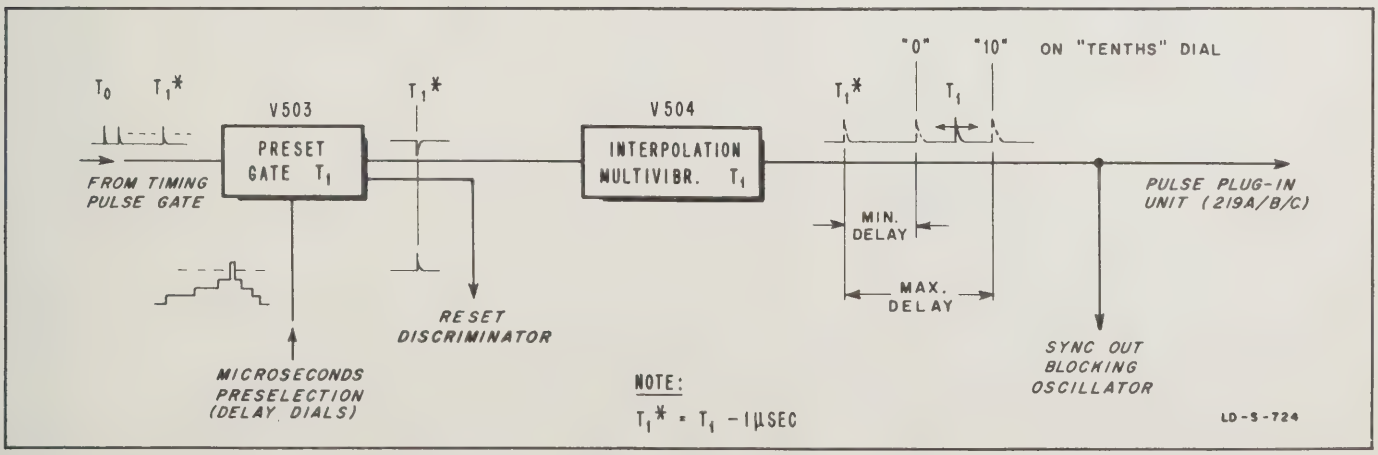


Figure 4-15. Preset Gate and Interpolation Multivibrator

a. When the beam does not form in the unit decade tube, junction of R343 and R344 rises suddenly toward 0 volt, causing both neon lamps DS303 and DS305 to ignite.

b. Capacitor C307 discharges through the lamps keeping the two lamps lit momentarily. The lamps extinguish since operating current for the lamps cannot be maintained through R310.

c. After the lamps are extinguished, capacitor C307 is charged negatively through R310 (determining the time constant) until the firing voltage of the lamps is reached again.

d. The sharp voltage rise of junction R310 and C307 is fed to the reset blocking oscillator V603 through capacitor C308.

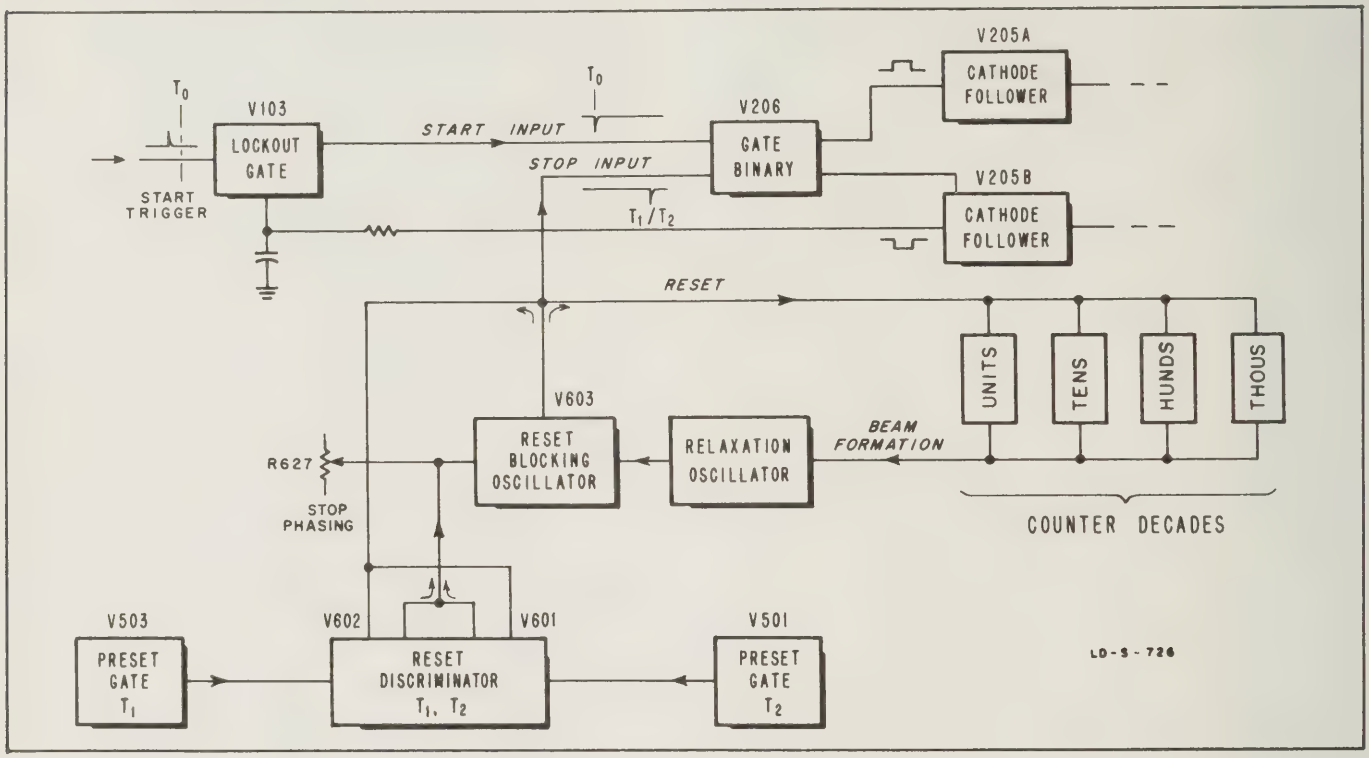


Figure 4-16. Reset Circuits

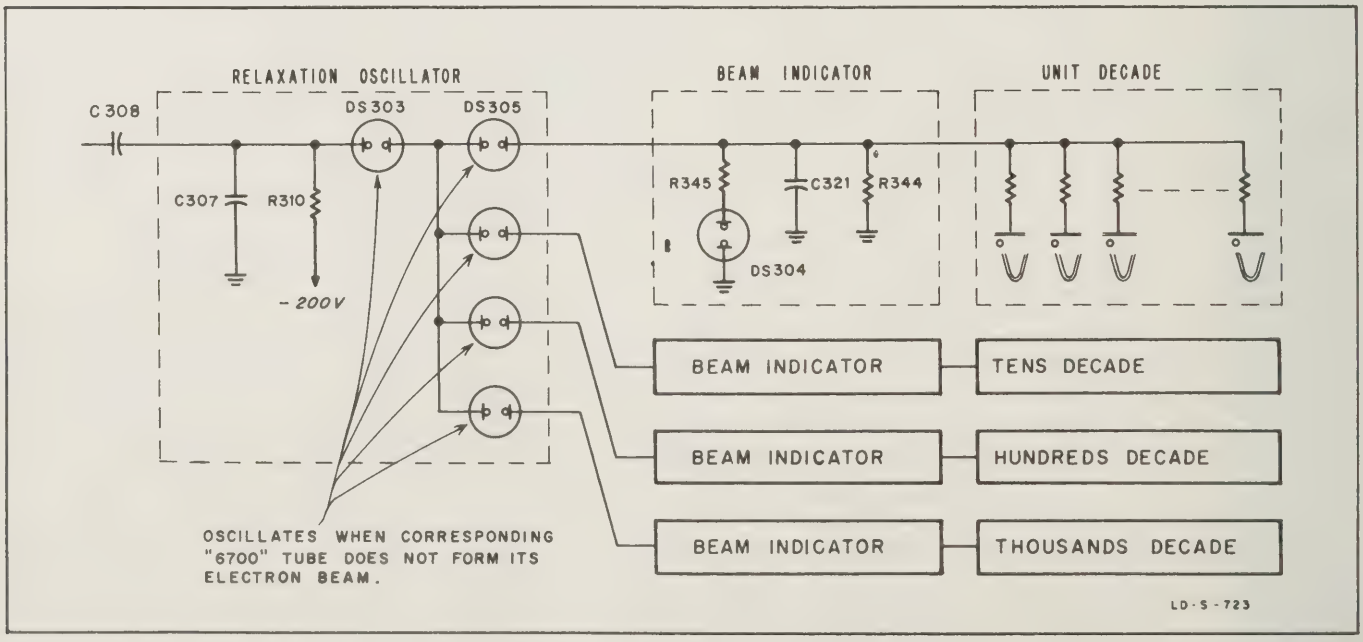


Figure 4-17. Relaxation Oscillator

4-89. SYNC OUT BLOCKING OSCILLATOR.

4-90. The sync out blocking oscillator V907 is located on the power supply deck. Sync selector switch S902 feeds one of the three timing pulses T_0, T_1 or T_2 to the input of a triode amplifier (pin 1, 2, 3 of V907). The amplifier is plate-coupled to a conventional blocking oscillator.

4-91. The sync out pulse has an amplitude of approximately 50 volts, a pulse width of 2 μsec and a rise time of 0.1 μsec. The source impedance is 50 ohms.

4-92. REGULATED POWER SUPPLIES.

4-93. The four supplies are of the conventional series regulated type (see figure 4-18). Plug-in unit 219C requires a higher current in the -200 volt supply. Additional series tubes located in the plug-in units are connected in parallel with the series tubes of the -200 volt supply. A cathode follower in the -200 volt control circuit lowers the impedance level of the control signal to minimize stray pickup (reducing ripple in the regulated output.

4-94. The -95 volt supply can only be adjusted, when the electron beams in all four type 6700 counter tubes are formed. The formation of the beam is indicated by neon lamps (see paragraph 5-7).

4-95. CLAMP VOLTAGES.

4-96. Breakdown diodes provide regulated bias voltages. These diodes are CR104, CR210, CR211, CR312, CR606, and CR918. The voltages at which these breakdown diodes regulate are marked on the schematic for each diode.

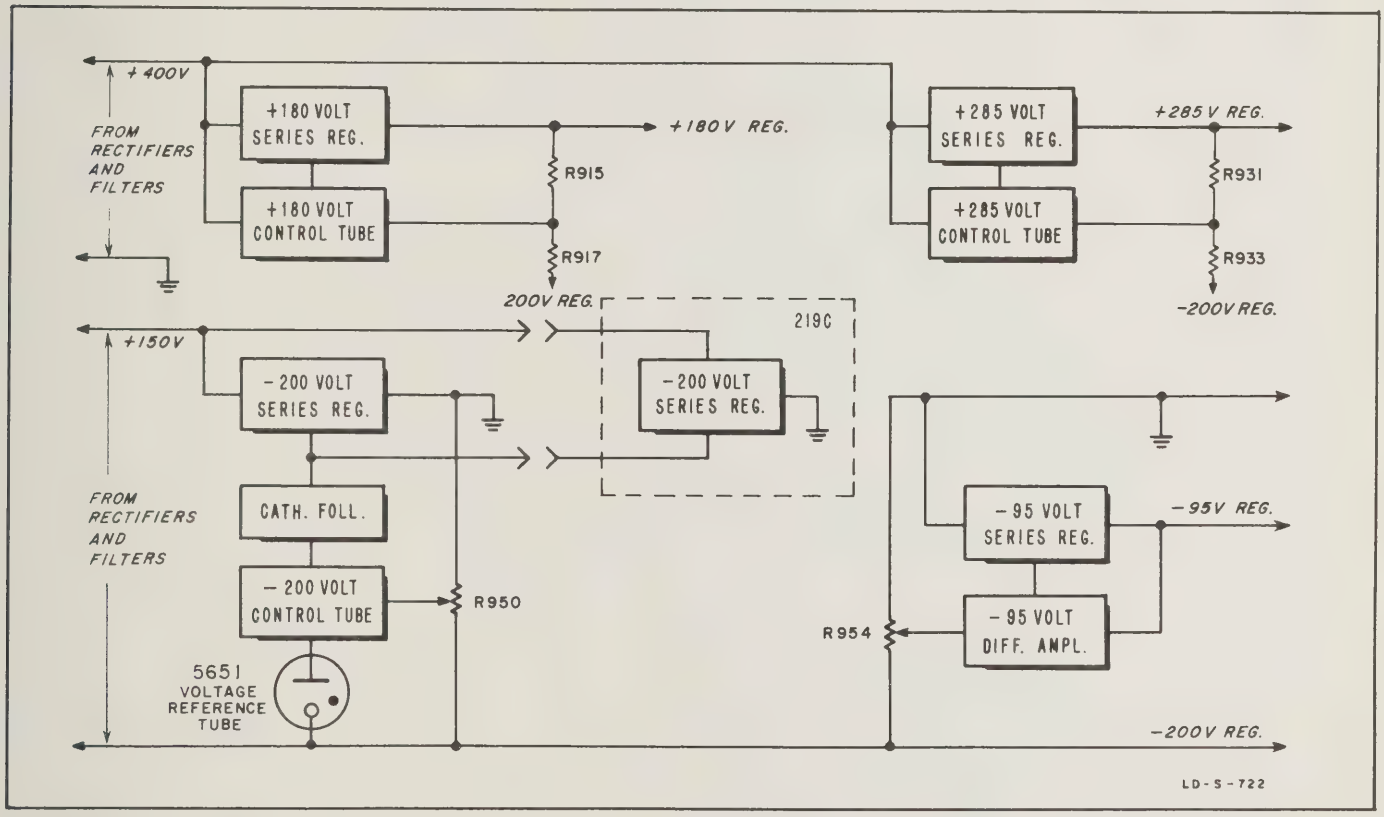


Figure 4-18. Regulated Power Supplies

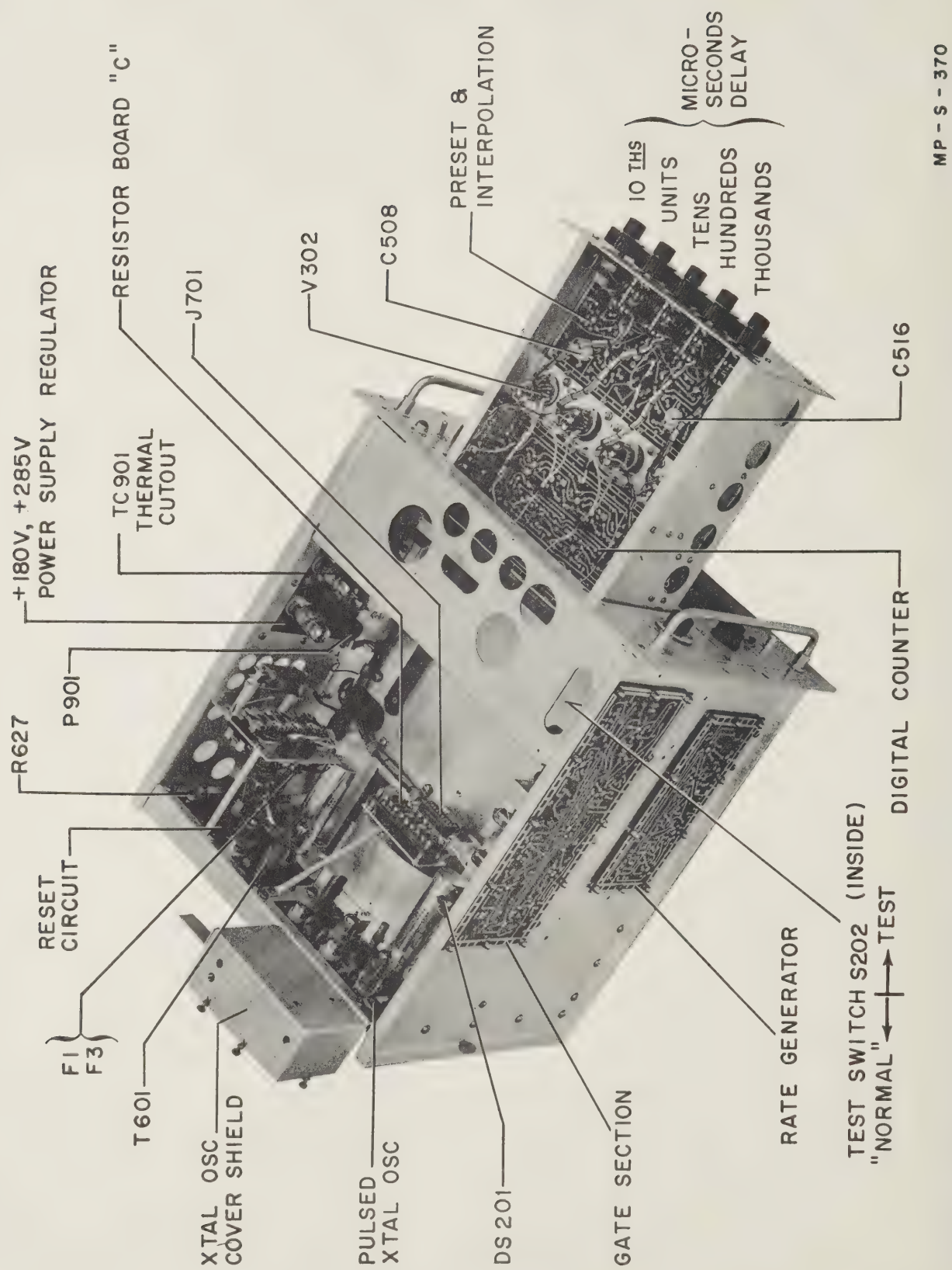


Figure 5-1. General Internal View Showing Etched Circuit Boards Location

SECTION V
MAINTENANCE

5-1. INTRODUCTION.

5-2. This section contains test and maintenance information for Model 218A Digital Delay Generator. A performance check is included that may be used to verify normal operation. This check is made with the instrument in its cabinet and serves as a routine or incoming inspection check. This section also includes recommended test equipment, troubleshooting, repair and adjustment procedures.

5-3. CLEANING THE AIR FILTER.

5-4. Inspect the air filter regularly, and clean before it becomes dirty enough to restrict air flow.

a. Remove filter from instrument rear, and wash it in warm water and detergent.

b. Dry filter thoroughly and coat it with filter adhesive. We recommend Filter Coat No. 3 from Research Products Company, Inc. This adhesive comes in "Handi-Koter" sprayer cans and is available from most heating supply stores or from your authorized Hewlett-Packard sales representative.

5-5. TEST EQUIPMENT.

5-6. Test equipment recommended for use in maintaining and servicing the Model 218A is listed in table 5-1. Equipment having similar characteristics can be substituted for the equipment listed.

5-7. TROUBLESHOOTING.

5-8. Before you start troubleshooting or making any adjustments take a few minutes and become familiar with the principle of operation of the instrument.

5-9. Section IV provides theoretical information (block diagrams, over-all operation, description of circuits, etc.).

5-10. Paragraphs 5-44 through 5-57 describe the correct sequence of adjustments and checks to set the instrument in proper operating condition.

5-11. DO NOT make any adjustments hastily if the instrument is not working. The instrument will not function due to:

Table 5-1. Recommended Test Equipment

Instrument Type	Required Characteristics	Model
DC Voltmeter	Voltage Accuracy: 3% Input Impedance: 100 megohms Range: 1 to 1000 v	hp Model 410B or hp Model 412A
AC Voltmeter	Voltage Accuracy: 5% Input Impedance: 10 megohms Frequency Range: 10 cps to 4 mc Range: 0.1 mv to 300 volts	hp Model 400D
Oscilloscope	Passband: dc to 10 mc Sensitivity: 5 mv/cm Input Impedance: At least 9 megohms	hp Model 150A with hp 152 Plug-In hp Model 170A with hp 162A Plug-In
Electronic Counter	Frequency Range: 10 cps to 10.1 mc Time Intervals: up to 10,000 μsec Accuracy: ±0.001% ±0.1 μsec	hp Model 524C/D with hp 526B Plug-In hp Model 5243L
Oscillator	Frequency Range: 5 cps to 600 kc Output: At least 0.5 volt rms	hp Model 200CD
Square Wave Generator	Frequency Range: 1 cps to 1 mc Output: At least 0.5 volt rms	hp Model 211A
Variable Transformer	Output Voltage: 103 - 127 volts Output Current: 5 amps	Power Stat Type 116

a. Incorrect setting of controls and switches.

b. Failure of tubes or other components.

c. No electron beam formation.

5-12. PRELIMINARY CHECKS.

5-13. SETTING OF CONTROLS AND SWITCHES.

a. Switch S202, located in upper right-hand corner of timing pulse circuit board, should be in position NORMAL.

b. COUNTED FREQ. switch should be in position INT 1 MC, if internal time base is used.

c. Check MICROSECOND DELAY controls for correct setting. Set unused delay on 0001.0 μsec (see paragraph 3-5).

5-14. NO ELECTRON BEAM FORMATION.

5-15. The Model 218A instrument will not operate if one of the type 6700 decade tubes has not formed its electron beam. The beam will not form if:

a. No reset pulse from the reset blocking oscillator.

b. Tube is defective (magnetic field, filament).

c. Tube intermittent.

d. Magnetic materials (bolts, tools) pulled up by magnet around tube.

5-16. NO RESET PULSE. A reset pulse will be triggered by the relaxation oscillator until the beam is formed, and the unit operates properly.

5-17. For test purposes the 6700 beams may be formed by touching a 0.1 μf capacitor (shunted with a 1-megohm resistor) between the brown reset lead (top rear of counter plug-in unit of Model 218A) and -200 volts.

5-18. TUBE INTERMITTENT. Normal operating 6700 tubes will not form their electron beam when Model 218A is turned on, even with all conditions for the beam formation fulfilled. Refer to paragraph 4-77 for detailed information.

5-19. Indicator lamps DS301, DS304, DS306, and DS308 light when the electron beam has formed correctly.

5-20. FAILURE OF COMPONENTS.

5-21. If a tube is suspected and the trouble symptom does not disappear when replacing a tube, put original tube back.

5-22. When replacing a component refer to list of replaceable parts in Section VI of this manual.

5-23. TROUBLE LOCALIZATION CHART.

5-24. The Trouble Localization Chart, figure 5-2, relates trouble symptoms and their removal in a systematic way. Proceed as follows:

a. Start in the upper left corner. Perform check as indicated in box (output pulse T_1/T_2).

b. If checks turn out positive, follow horizontal line to the right.

c. If checks turn out negative (no output pulse) follow vertical line down. The line will lead to another check or to an adjustment with reference to a paragraph.

d. A dotted line leads you back to a check done previously (after having made an adjustment or a component replacement). The check should be repeated.

5-25. WAVEFORMS.

5-26. In pulse circuit work waveforms convey useful information. A complete series of waveforms is given in table 5-2 as an aid for servicing the instrument. The waveforms show in a systematic way the time relationship of the signals in the different circuits.

5-27. Test equipment required: High Speed Oscilloscope, Model 150A or equivalent, Model 151A High Gain Amplifier Plug-In Unit, Model 152B Dual Trace Amplifier Plug-In Unit.

Note

All waveform voltage references are ac-coupled unless otherwise specified.

5-28. REPAIR AND REPLACEMENT.

5-29. CABINET REMOVAL.

5-30. To remove the dust cover from the Model 218A proceed as follows:

a. Tilt the instrument on its front side, so it is supported by its two handles.

b. Remove the two screws in the back of the dust cover.

c. Lift the dust cover while feeding the power cord through the hole in the rear of the cover.

5-31. SERVICING ETCHED CIRCUIT BOARDS.

Note

Excessive heat or pressure can lift copper conductors from etched circuit boards.

5-32. To remove components from board, clip leads on component side of board. New components can then be soldered to the leads extending from the board or the leads can be removed. If leads are removed, clean holes with a toothpick (metal awls or soldering aids may destroy plating in the hole) before inserting leads.

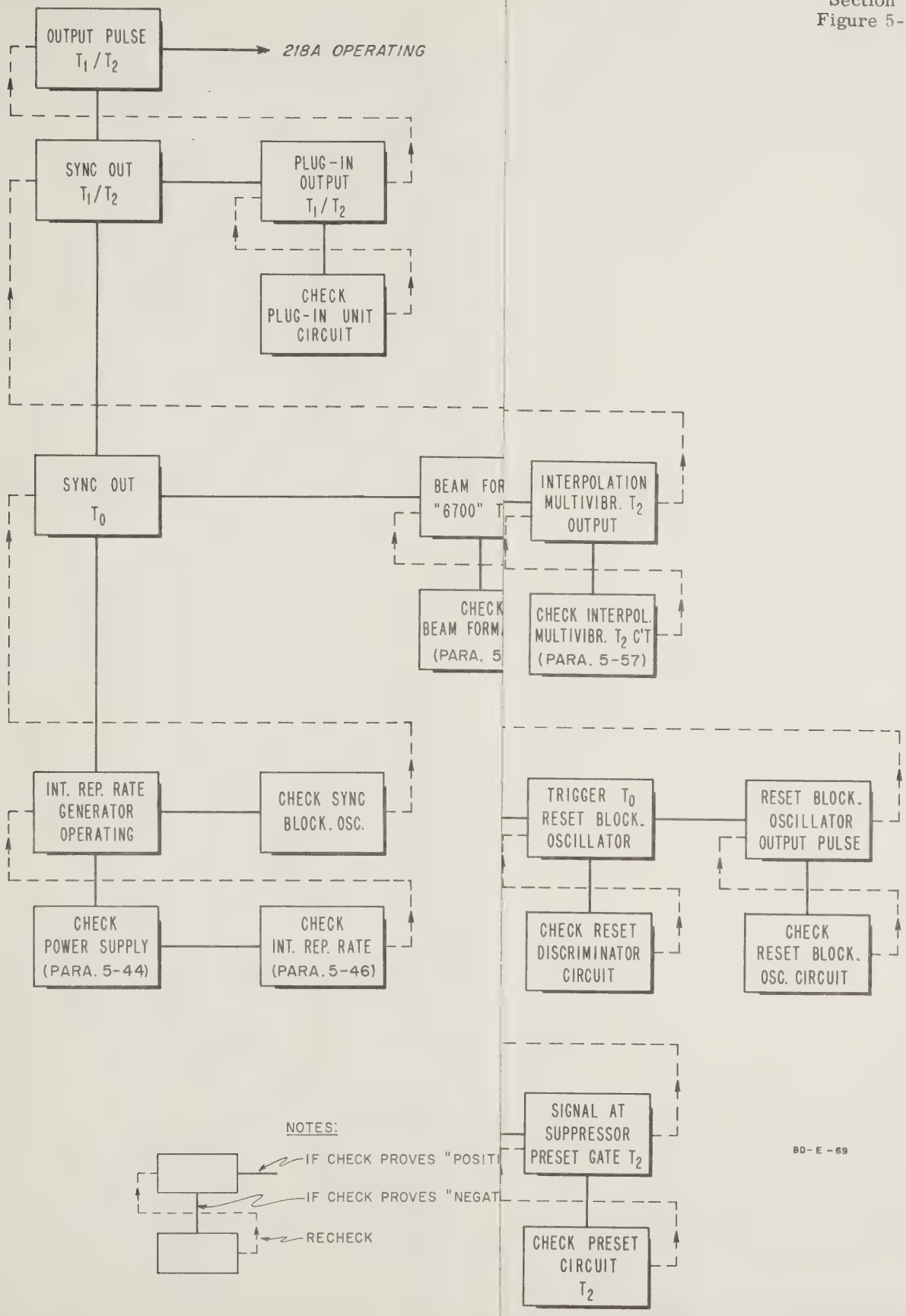


Figure 5-2. Troubleshooting

a. Incorrect setting of controls and switches.

b. Failure of tubes or other components.

c. No electron beam formation.

5-12. PRELIMINARY CHECKS.

5-13. SETTING OF CONTROLS AND SWITCHES.

a. Switch S202, located in upper right-hand corner of timing pulse circuit board, should be in position NORMAL.

b. COUNTED FREQ. switch should be in position INT 1 MC, if internal time base is used.

c. Check MICROSECOND DELAY controls for correct setting. Set unused delay on 0001.0 μsec (see paragraph 3-5).

5-14. NO ELECTRON BEAM FORMATION.

5-15. The Model 218A instrument will not operate if one of the type 6700 decade tubes has not formed its electron beam. The beam will not form if:

a. No reset pulse from the reset blocking oscillator.

b. Tube is defective (magnetic field, filament).

c. Tube intermittent.

d. Magnetic materials (bolts, tools) pulled up by magnet around tube.

5-16. NO RESET PULSE. A reset pulse will be triggered by the relaxation oscillator until the beam is formed, and the unit operates properly.

5-17. For test purposes the 6700 beams may be formed by touching a 0.1 μf capacitor (shunted with a 1-megohm resistor) between the brown reset lead (top rear of counter plug-in unit of Model 218A) and -200 volts.

5-18. TUBE INTERMITTENT. Normal operating 6700 tubes will not form their electron beam when Model 218A is turned on, even with all conditions for the beam formation fulfilled. Refer to paragraph 4-77 for detailed information.

5-19. Indicator lamps DS301, DS304, DS306, and DS308 light when the electron beam has formed correctly.

5-20. FAILURE OF COMPONENTS.

5-21. If a tube is suspected and the trouble symptom does not disappear when replacing a tube, put original tube back.

5-22. When replacing a component refer to list of replaceable parts in Section VI of this manual.

5-23. TROUBLE LOCALIZATION CHART.

5-24. The Trouble Localization Chart, figure 5-2, relates trouble symptoms and their removal in a systematic way. Proceed as follows:

a. Start in the upper left corner. Perform check as indicated in box (output pulse T_1/T_2).

b. If checks turn out positive, follow horizontal line to the right.

c. If checks turn out negative (no output pulse) follow vertical line down. The line will lead to another check or to an adjustment with reference to a paragraph.

d. A dotted line leads you back to a check done previously (after having made an adjustment or a component replacement). The check should be repeated.

5-25. WAVEFORMS.

5-26. In pulse circuit work waveforms convey useful information. A complete series of waveforms is given in table 5-2 as an aid for servicing the instrument. The waveforms show in a systematic way the time relationship of the signals in the different circuits.

5-27. Test equipment required: High Speed Oscilloscope, Model 150A or equivalent, Model 151A High Gain Amplifier Plug-In Unit, Model 152B Dual Trace Amplifier Plug-In Unit.

Note

All waveform voltage references are ac-coupled unless otherwise specified.

5-28. REPAIR AND REPLACEMENT.

5-29. CABINET REMOVAL.

5-30. To remove the dust cover from the Model 218A proceed as follows:

a. Tilt the instrument on its front side, so it is supported by its two handles.

b. Remove the two screws in the back of the dust cover.

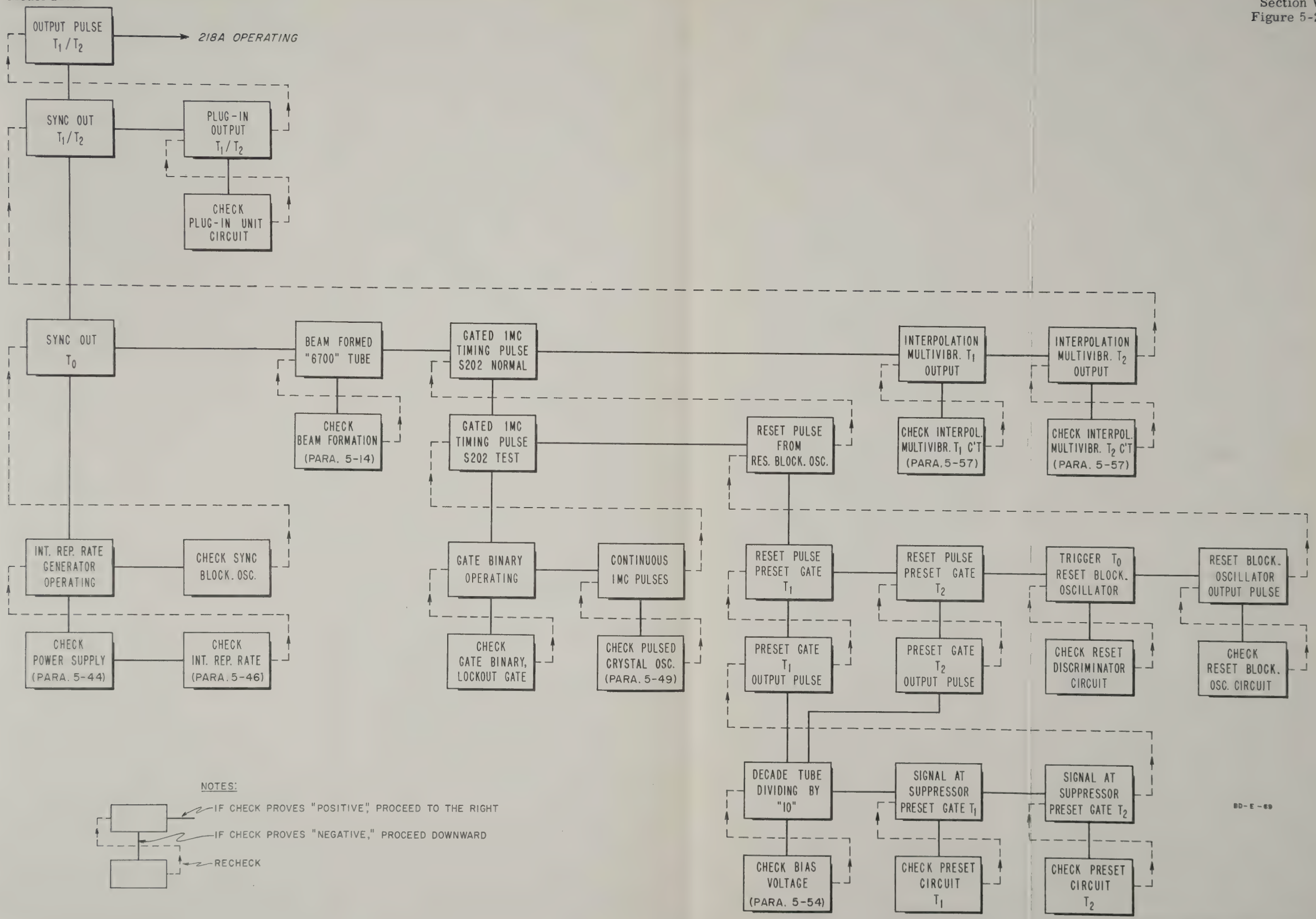
c. Lift the dust cover while feeding the power cord through the hole in the rear of the cover.

5-31. SERVICING ETCHED CIRCUIT BOARDS.

Note

Excessive heat or pressure can lift copper conductors from etched circuit boards.

5-32. To remove components from board, clip leads on component side of board. New components can then be soldered to the leads extending from the board or the leads can be removed. If leads are removed, clean holes with a toothpick (metal awls or soldering aids may destroy plating in the hole) before inserting leads.



00095-1

Figure 5-2. Troubleshooting

Table 5-2. Waveforms

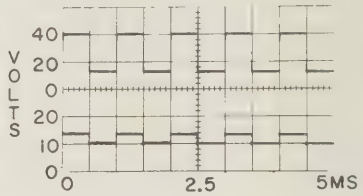
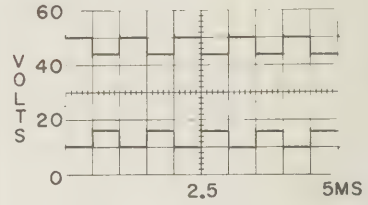
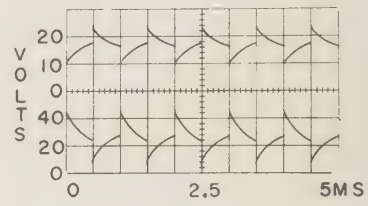
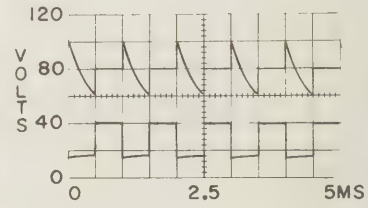
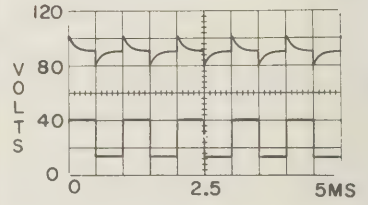
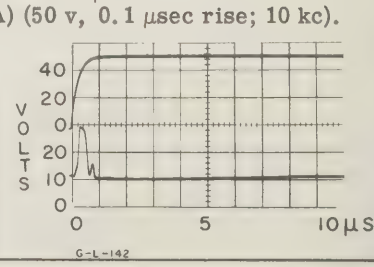
No.	Oscilloscope	Test Points	Waveforms
	Internal Repetition Rate Generator		
	Model 218A Settings:	Switch S202 to NORMAL, set T_1 and T_2 to 0002.0 μsec. Set Internal Pulse Repetition Rate to 1 kc.	
1.	Sweep: 500 μsec/cm Sync: + INT	Pin 1, plate of V102B Pin 7, grid 1 of V101A	
2.	Same as 1.	Pin 8, cathode of V101A Pin 6, plate of V101A	
3.	Same as 1.	Pin 2, grid 1 of V101B Pin 1, plate of V101B	
4.	Same as 1.	Pin 3/8, cathode of V102A/B Pin 6, plate of V102A	
5.	Same as 1.	Pin 2, grid of V102B Pin 1, plate of V102B	
	Input Circuit on External Trigger		
	Model 218A Settings:	Switch S202 to NORMAL; set T_1 and T_2 to 0002.0 μsec. Trigger with square wave (Ⓗ Model 211A) (50 v, 0.1 μsec rise; 10 kc).	
6.	Sweep: 1 μsec/cm Sync: + EXT use external trigger of Model 218A	Pin 6, J103, typical EXT. TRIGGER pulse Pin 1, V103, control grid lockout gate.	

Table 5-2. Waveforms (Cont'd)

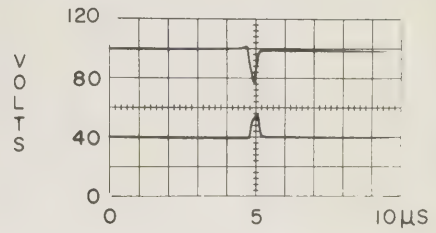
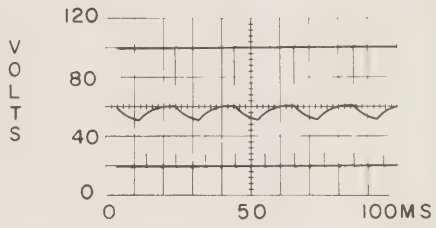
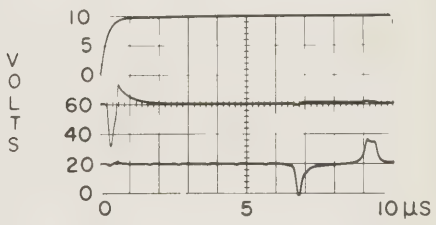
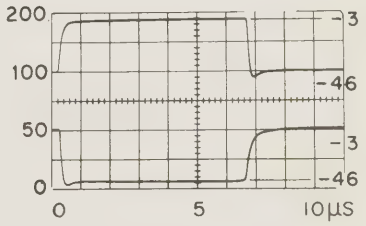
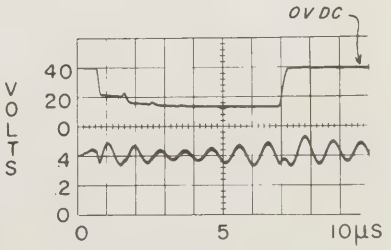
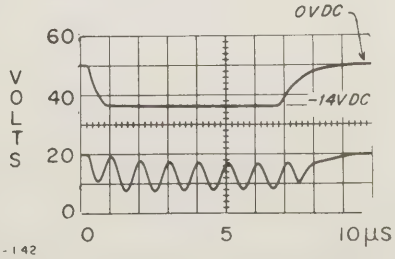
No.	Oscilloscope	Test Points	Waveforms
	Input Circuit on External Trigger (Cont'd)		
7.	Same as 6.	Pin 7, of T101, Primary Pin 5 of T102, secondary	
8.	Same as 6.	Set T_1 and T_2 to 0200.0 µsec Set pulse repetition rate to 100 cps Pin 5, plate of LOCKOUT GATE V103 Pin 7, SUPPRESSOR of LOCKOUT GATE V103 Pin 1, control grid of LOCKOUT GATE V103	
	Pulsed Crystal Oscillator		
	Model 218A Settings:	Switch S202 to NORMAL, set T_1 to 4.0 µsec, T_2 to 6.0 µsec. Trigger with square wave (hp 211A) (20 v, 0.1 µsec rise, 10 kc repetition rate).	
9.	Sweep: 1 µsec/cm, Sync: + EXT use external trigger pulse of Model 218A	Pin 6, J103, EXT. TRIGGER pulse Start INPUT at test point between R270 and S202 Stop INPUT at test point between R256 and S202	
10.	Same as 9. Vert. Input - DC	Pin 6 of V206, plate gate control binary. Pin 1 of V203, plate gate control binary	
11.	Same as 9. Vert. Input - DC	Pin 7, suppressor grid of crystal gate V207 Pin 1, control grid of 1 mc limiter V209	
12.	Same as 9. Vert. Input - DC	Pin 7, control grid of 1 mc ringer V210 Pin 3/8, cathode of 1 mc ringer V210	

Table 5-2. Waveforms

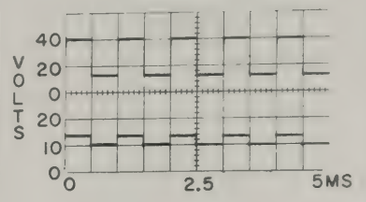
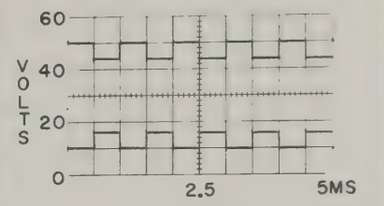
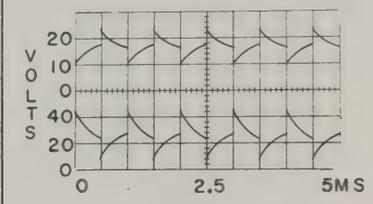
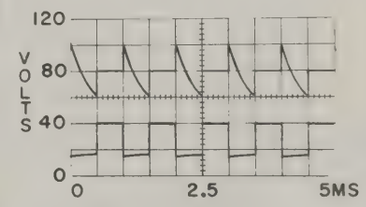
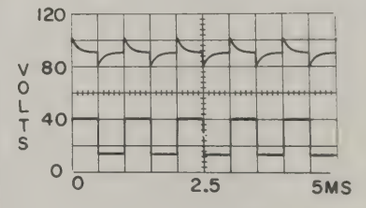
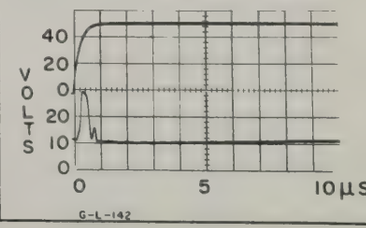
No.	Oscilloscope	Test Points	Waveforms
	Internal Repetition Rate Generator		
	Model 218A Settings:	Switch S202 to NORMAL, set T_1 and T_2 to 0002.0 μsec. Set Internal Pulse Repetition Rate to 1 kc.	
1.	Sweep: 500 μsec/cm Sync: + INT	Pin 1, plate of V102B Pin 7, grid 1 of V101A	
2.	Same as 1.	Pin 8, cathode of V101A Pin 6, plate of V101A	
3.	Same as 1.	Pin 2, grid 1 of V101B Pin 1, plate of V101B	
4.	Same as 1.	Pin 3/8, cathode of V102A/B Pin 6, plate of V102A	
5.	Same as 1.	Pin 2, grid of V102B Pin 1, plate of V102B	
	Input Circuit on External Trigger		
	Model 218A Settings:	Switch S202 to NORMAL; set T_1 and T_2 to 0002.0 μsec. Trigger with square wave (ℎ𝑝 Model 211A) (50 v, 0.1 μsec rise; 10 kc).	
6.	Sweep: 1 μsec/cm Sync: + EXT use external trigger of Model 218A	Pin 6, J103, typical EXT. TRIGGER pulse Pin 1, V103, control grid lockout gate.	

Table 5-2. Waveforms (Cont'd)

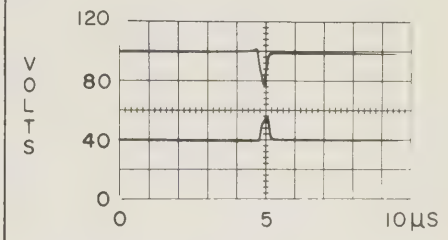
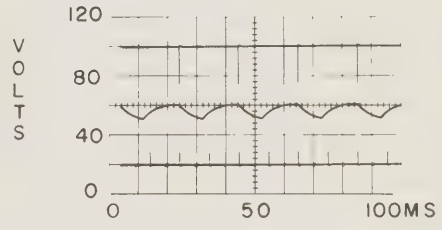
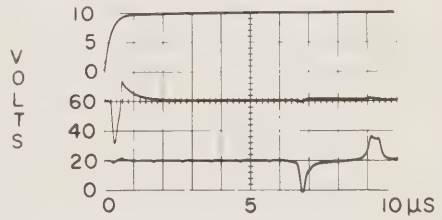
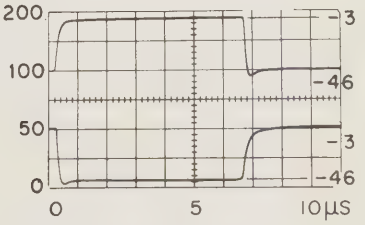
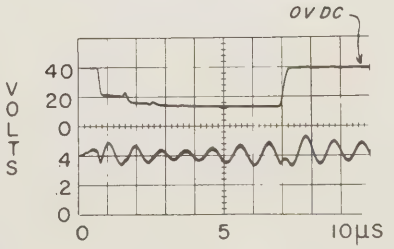
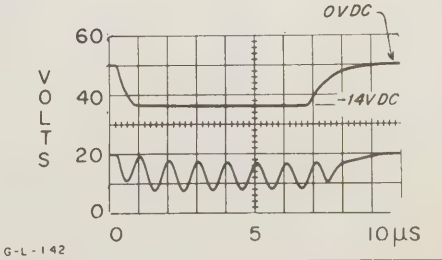
No.	Oscilloscope	Test Points	Waveforms
	Input Circuit on External Trigger (Cont'd)		
7.	Same as 6.	Pin 7, of T101, Primary Pin 5 of T102, secondary	
8.	Same as 6.	Set T_1 and T_2 to 0200.0 µsec Set pulse repetition rate to 100 cps Pin 5, plate of LOCKOUT GATE V103 Pin 7, SUPPRESSOR of LOCKOUT GATE V103 Pin 1, control grid of LOCKOUT GATE V103	
	Pulsed Crystal Oscillator		
	Model 218A Settings:	Switch S202 to NORMAL, set T_1 to 4.0 µsec, T_2 to 6.0 µsec. Trigger with square wave (hp 211A) (20 v, 0.1 µsec rise, 10 kc repetition rate).	
9.	Sweep: 1 µsec/cm, Sync: + EXT use external trigger pulse of Model 218A	Pin 6, J103, EXT. TRIGGER pulse Start INPUT at test point between R270 and S202 Stop INPUT at test point between R256 and S202	
10.	Same as 9. Vert. Input - DC	Pin 6 of V206, plate gate control binary. Pin 1 of V206, plate gate control binary	
11.	Same as 9. Vert. Input - DC	Pin 7, suppressor grid of crystal gate V207 Pin 1, control grid of 1 mc limiter V209	
12.	Same as 9. Vert. Input - DC	Pin 7, control grid of 1 mc ringer V210 Pin 3/8, cathode of 1 mc ringer V210	

Table 5-2. Waveforms (Cont'd)

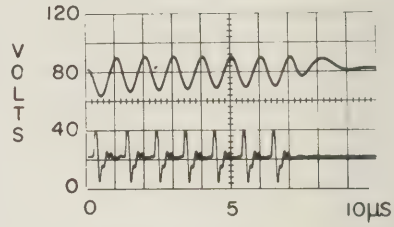
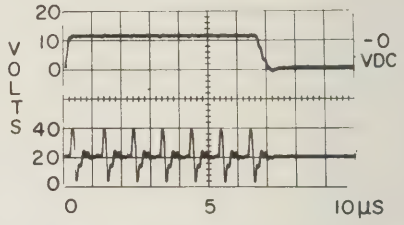
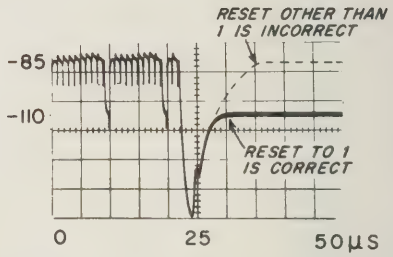
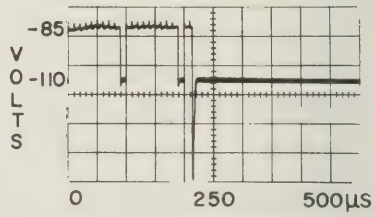
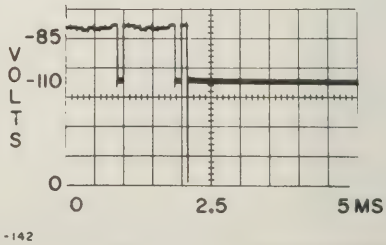
No.	Oscilloscope	Test Points	Waveforms
	Pulsed Crystal Oscillator (Cont'd)		
13.	Same as 9.	Pin 2, plate of 1 mc amplifier V201 Pin 5, secondary of T201	
14.	Same as 9. Vert. Input - DC	Pin 7, suppressor grid of TIMING PULSE GATE V207 Pin 3, secondary of T202, gated timing pulses	
	Unit Decade Reset		
	Model 218A Settings:	Switch S202 to NORMAL, set T_1 and T_2 to 0022.0 µsec. Set pulse repetition rate to 1 kc.	
15.	Sweep: 5 µsec/cm Sync: SYNC OUT of T_0. Probe: Brown wire S301 (UNIT) Vert. Input - DC	Division by "10" and RESET to "1"	
	Tens Decade Reset		
	Model 218A Settings:	Switch S202 to NORMAL, set T_1 and T_2 to 0222.0 µsec. Set pulse repetition rate to 100 cps.	
16.	Sweep: 50 µsec Sync: SYNC OUT T_0 Probe: Black wire S302 (TENS) Vert. Input - DC	Division by "10" and RESET to "0"	
	Hundreds Decade Reset		
	Model 218A Settings:	Switch S202 to NORMAL, set T_1 and T_2 to 2222.0 µsec Set pulse repetition rate to 100 cps.	
17.	Sweep: 500 µsec/cm Sync: SYNC OUT T_0 Probe: Black wire (HUNDREDS) Vert. Input - DC	Division by "10" and RESET to "0"	

Table 5-2. Waveforms (Cont'd)

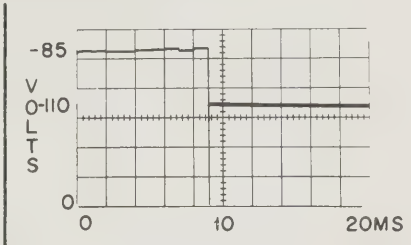
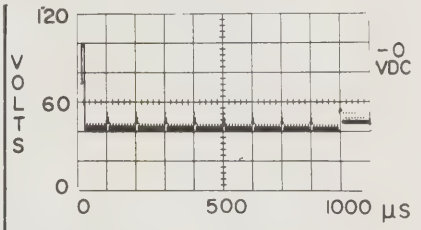
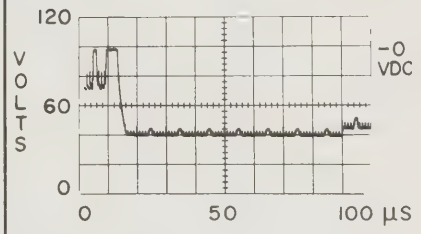
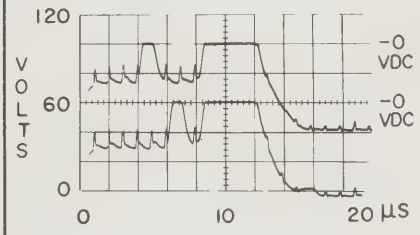
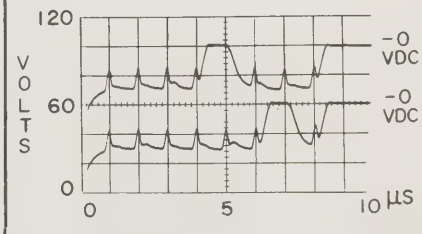
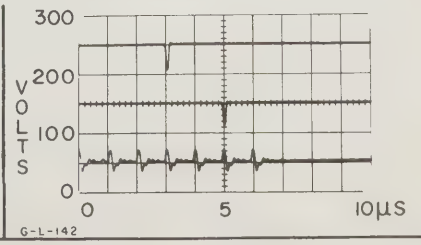
No.	Oscilloscope	Test Points	Waveforms
	Thousands Decade Reset Model 218A Settings:	Switch S202 to NORMAL, set T_1 and T_2 to 10,000 μsec (000.0). Set pulse repetition rate to 25 cps.	
18.	Sweep: 2 mc/cm Sync: SYNC OUT T_0 Probe: Black wire S304 (THOUSANDS) Vert. Input - DC	Division by "10" and RESET to "0"	
	Preset Gate Model 218A Settings:	Switch S202 to TEST. Set T_1 to 0004.0, T_2 to 0006.0. START PULSE SELECTOR on + EXT., PUSH MANUAL TRIGGER	
19.	Sweep: 200 μsec/cm Sync: EXT at black wire of S304 (THOUSANDS selector switch) Vert. Input - DC	Pin 7 of V503, Preset Gate T_1 Pin 7 of V501, Preset Gate T_2	
20.	Same as 19, except 20 μsec/cm Vert. Input - DC	Pin 7 of V503, Preset Gate T_1 Pin 7 of V501, Preset Gate T_2	
21.	Same as 19, except 2 μsec/cm Vert. Input - DC	Pin 7 of V503, Preset Gate T_1 Pin 7 of V501, Preset Gate T_2	
22.	Same as 19, except 1 μsec/cm Vert. Input - DC	Pin 7 of V503, Preset Gate T_1 Pin 7 of V501, Preset Gate T_2	
	Interpolation Multivibrator Model 218A Settings:	Switch S202 to NORMAL, set T_1 to 0004.0 and T_2 to 0006.0.	
23.	Sweep: 1 μsec/cm Sync: + EXT, use SYNC OUT of Model 218A at T_0	Pin 5 of V503, trigger to interpolation multivibrator T_1 Pin 5 of V501, trigger to interpolation multivibrator T_2	

Table 5-2 Waveforms (Cont'd)

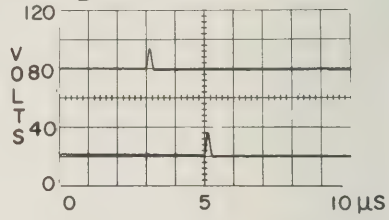
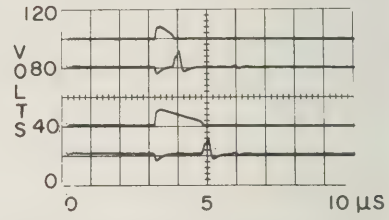
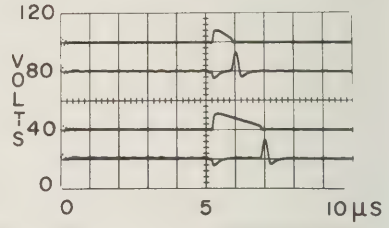
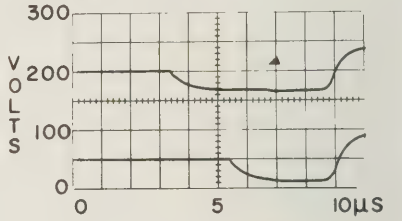
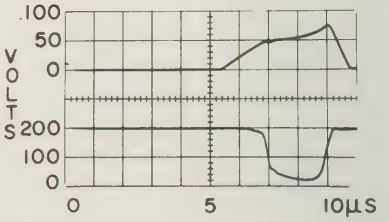
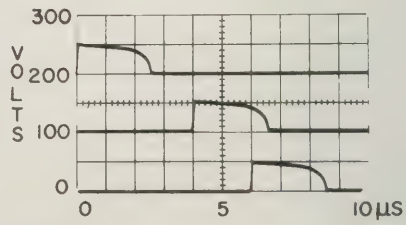
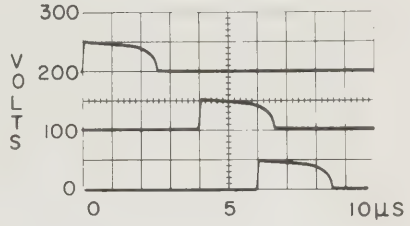
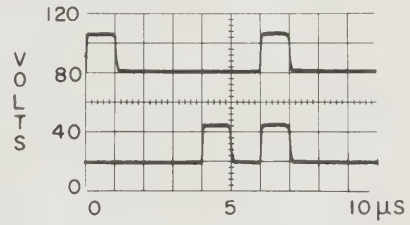
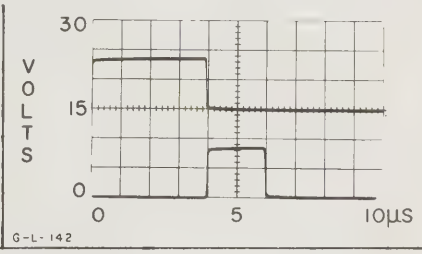
No.	Oscilloscope	Test Points	Waveforms
	Interpolation Multivibrator (Cont'd) 218A Settings: Switch S202 to NORMAL, set T_1 to 0004.0 and T_2 to 0006.0		
24.	Same as 23.	Pin 5 of T502, trigger to reset discriminator T_1 Pin 5 of T501, trigger to reset discriminator T_2	
25.	Same as 23.	Pin 3 of V504, int. multivibrator — TENTHS at "0" at "10" Pin 1 of V504 — TENTHS at "0" at "10"	
26.	Same as 23.	Pin 3 of V502, int. multivibrator — TENTHS at "0" Pin 1 of V502 — TENTHS at "10"	
	Reset Circuit Model 218A Settings: Switch S202 to NORMAL, set T_1 to 0004.0 and T_2 to 0006.0.		
27.	Sweep: 1 μsec/cm Sync: + EXT use SYNC OUT of Model 218A at T_0	Pin 1 of V602, reset discriminator T_1 Pin 1 of V601, reset discriminator T_2	
28.	Same as 27.	Pin 6 of V601, trigger to blocking oscillator Pin 9 of V603, reset pulse	
	Sync. Output Pulse Model 218A Settings: Switch S202 to NORMAL, set T_1 to 0004.0 μsec, T_2 to 0006.0 μsec. Set pulse repetition rate to 1 kc.		
29.	Sweep: 1 μsec/cm Sync: + EXT, use START PULSE of GATE CONTROL BINARY V206	SYNC. OUT JACK — T_0, T_1 Selector switch at — T_2	

Table 5-2. Waveforms (Cont'd)

No.	Oscilloscope	Test Points	Waveforms
30.	Model 219A - Output Pulse Model 218A Settings: Same as in (29) Sweep: 1 μsec/cm Sync: + EXT, use SYNC. OUT of Model 218A at T_0	OUTPUT PULSE A at T_0, T_1 OUTPUT PULSE B at T_2	
31.	Model 219B - Output Pulse Model 218A Settings: Same as in (29) Model 210B Settings: Both Outputs: AMPLITUDE: 20 VOLTS, WIDTH: 1 μsec POLARITY: positive, OUTPUT: COM. Same as in (30)	OUTPUT PULSE A at T_0 OUTPUT PULSE B at T_2 OUTPUT PULSE A at T_1 OUTPUT PULSE B at T_2	
32.	Model 219C - Output Pulse Model 218A Settings: Same as in (29) Model 219C Settings: Both Outputs: AMPLITUDE: 10 VOLTS, OUTPUT: 90 OHMS Same as in (30)	Positive Output Pulse $T_0 - T_1$ Pulse Timing $T_1 - T_2$	

5-33. DIODE REPLACEMENT.

5-34. Replacement of most diodes is not critical. There are a few diodes that require a special check before replacing a damaged diode. Observe polarity and correct diode type when replacing a diode, as indicated by the silkscreening.

5-35. There are seven diode types used in the circuits of the Model 218A (excluding the rectifier diodes of the power supply circuits). The diodes are color coded and identified as indicated in figure 5-3. Diodes CR204 and CR205 (located in GATE BINARY STAGE V206) require a high back resistance. When applying 1.5 volts reverse bias, the back resistance should exceed 500,000 ohms at 21°C (70°F) and not decrease below 75,000 ohms at 65°C (150°F).

5-36. TUBE REPLACEMENT.

5-37. Some of the tubes used in the Model 218A require a circuit adjustment after replacement. Table 5-3 lists the tube, its location, and the adjustment or check required after replacement.

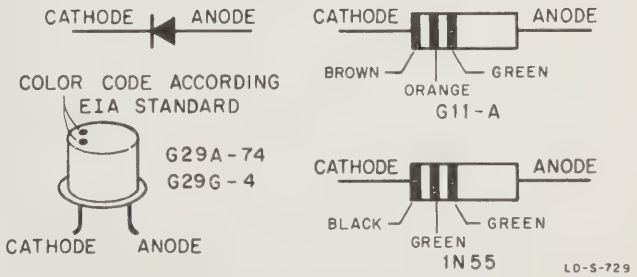


Figure 5-3. Diode Identification

5-38. Turn instrument off when replacing a tube. This applies in particular for tube V603 (Reset Blocking Oscillator). If V603 is replaced with the instrument on, excessive plate current will be flowing due to the absence of a space charge at the cathode. The result is a burn-out of resistor R618.

CAUTION

Each type 6700 Magnetron Beam tube is permanently mounted with a powerful magnet. Do

Table 5-3. Tube Replacement List

Tube No.	Tube Type	Location/Function	Adjustment/Check
V101	5965	Input Circuit Amplifier	Input Sensitivity, paragraph 5-46
V102	5965	Input Circuit Schmitt Trigger	Square Wave Symmetry, paragraph 5-46
V202	5654	1 MC Schmitt Trigger	Schmitt Trigger Check, paragraph 5-49
V203	5654	1 MC Schmitt Trigger	Schmitt Trigger Check, paragraph 5-49
V302	6700	Unit Decade	Bias Unit Decade, paragraph 5-54
V307	6700	Tens Decade	Bias Tens Decade, paragraph 5-54
V310	6700	Hundreds Decade	Bias Hundreds Decade, paragraph 5-54
V315	6700	Thousands Decade	Bias Thousands Decade, paragraph 5-54
V502	5965	Interpol. Multivibrator T_2	Min. and Max. Delay T_2, paragraph 5-7
V504	5965	Interpol. Multivibrator T_1	Min. and Max. Delay T_1, paragraph 5-7
V603	7119	Reset Block, Oscill.	Stop Phasing, paragraph 5-49. Turn off instrument when replacing V603.

not subject the magnets to strong mechanical shocks or allow magnets to come together. This can change the field symmetry, showing up as erratic functioning. Keep your watch away from magnets and do not allow it to come in contact with magnetic materials such as tools, metal shields, bolts, etc.

5-39. Certain brands of 5965 tubes do not have the pulse characteristics required for proper operation in the Model 218A and its associated plug-in units. When replacing a 5965 tube, check its performance under pulsed conditions by proceeding as follows:

a. Remove V1001 (of Model 219A plug-in unit) or V907 (if Model 219A plug-in is not available).

b. Install replacement 5965 tube whose pulse characteristics are to be determined.

c. Measure pulse amplitude at unloaded output jack A (or SYNC OUT jack) with oscilloscope.

d. Terminate output jack A with 50 ohms.

e. 5965 tube has good pulse characteristics if amplitude of terminated output is 40-50% of original value (see step c). An amplitude of 25% or less indicates poor characteristics.

5-40. PULSE TRANSFORMER REPLACEMENT.

5-41. There are five types of pulse transformers used in the Model 218A instrument. Transformers are marked with the ℌ stock number and coded by a color dot on the bottom of the transformer. Observe this when replacing a pulse transformer.

5-42. ADJUSTMENTS.

5-43. The following section is a complete procedure and should be made only if it has been definitely determined that the Model 218A is out of adjustment.

5-44. ADJUSTING THE POWER SUPPLIES.

5-45. The block diagram, figure 4-18, shows the interdependence of the four regulated power supplies, which are of the conventional series-regulated type. The value of the +180 and +285 volt supplies are permanently adjusted by precision resistors. To adjust the -95 and the -200 volt supplies, see figure 5-4 and proceed as follows:

a. Connect DC Voltmeter to CHK points for steps b through f.

b. Adjust R950 to obtain -200 volts.

c. Adjust R954 to obtain -95 volts ±1% (electron beam must be formed in type 6700 tubes; see paragraph 5-14).

d. Check Zener voltage: -7 volts reg. and -14 volts reg. CR210 and CR211 located on Timing Pulse circuit board.

e. Check Zener voltage: -15 volts reg. CR312 located on counter circuit board.

f. Slowly change line voltage from 103 to 127 volts. All regulated voltages should stay within 2 volts.

g. Connect AC Voltmeter to CHK points for step h.

h. Check ripple voltage. All regulated supplies should have less than 100 mv ripple.

CAUTION

Due to high dc current handling capacities of power supplies (approximately 900 ma in the -200 volt supply) be extra careful while making adjustments in the power supplies. Shorting a regulated supply will destroy all associated series tubes plus their corresponding cathode resistors. Fast-blow fuses are necessary in all rectifier circuits to provide adequate protection for the rectifiers.

5-46. ADJUSTING INPUT AND RATE GENERATOR.

5-47. Before starting with the adjustments make sure that the power supplies are set correctly. Refer to figure 5-5 and proceed in the sequence as shown in table 5-4.

Table 5-4. Adjusting Input/Rate Generator

218A Settings	Oscilloscope Settings	Adjustments
	SYMMETRY	
Set PULSE RATE to 50 Set START PULSE SELECTOR to X10 (Pulse repetition rate = 500 cps)	Sweep: 200 μsec/cm Sync: INT. Probe: pin 1 of V102	Adjust R114 for symmetrical square wave
	RATE	
Set START PULSE SELECTOR to X10 Set PULSE RATE to "dot" on dial	Sweep: 200 μsec/cm Sync: +INT. Probe: pin 1 of V102 Counter: pin 1 of V103	Adjust R112 for 1,500 cps (read counter)
	EXT. SENSITIVITY	
Set START PULSE SELECTOR to -EXT. Feed 1.5 rms at 1 kc to EXT. TRIG. input.	Sweep: 1 ms/cm Sync: +INT. Probe: pin 1 of V102	Set R108 fully clockwise. Adjust R124 clockwise from extreme counterclockwise position until circuit just triggers. Set R108 fully counterclockwise. Increase external 1 KC signal until circuit just triggers. Amplitude of trigger voltage no less than 10 volts rms.
	MANUAL TRIGGER	
Switch S202 in TEST. Set START PULSE SELECTOR to +EXT. No EXT. TRIG. signal	Sweep: 1 ms/cm Sync: INT. Probe: pin 3 T202	Depress MANUAL TRIGGER button. Gated timing pulses seen on scope. Depress again to stop pulses.

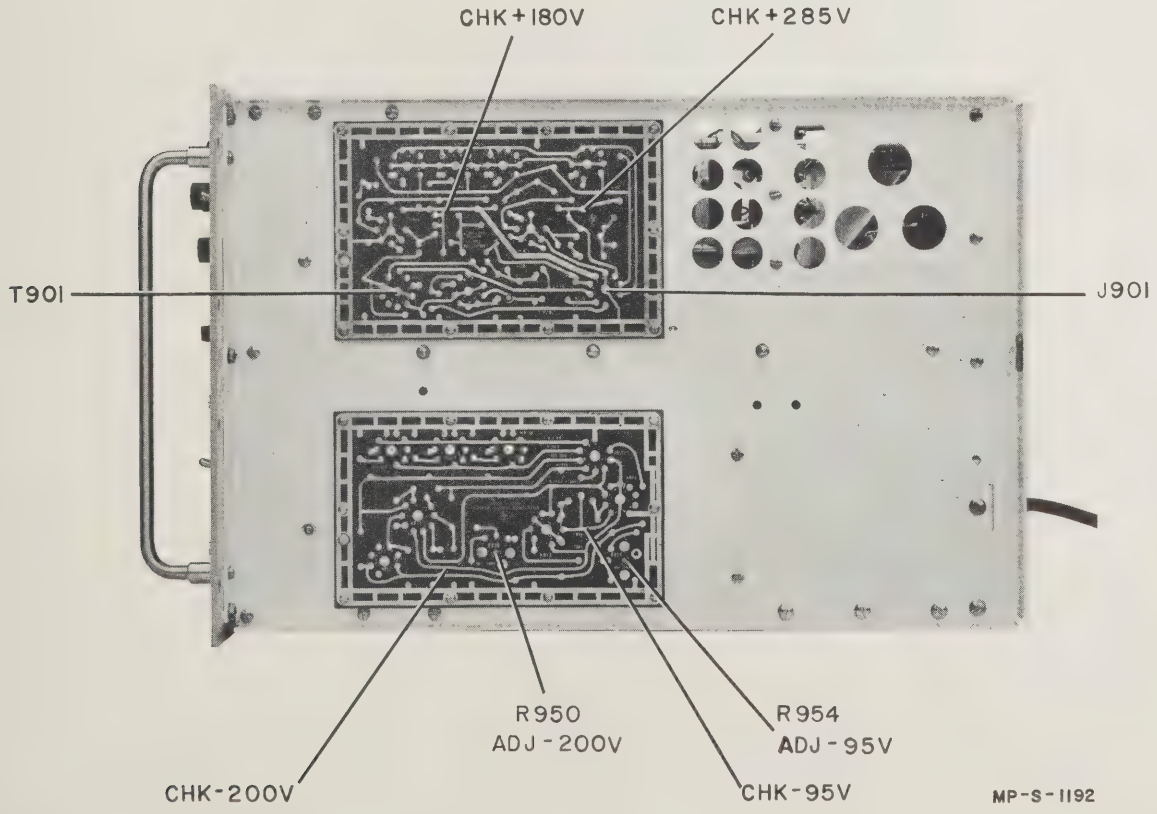


Figure 5-4. Model 218A Right Side View

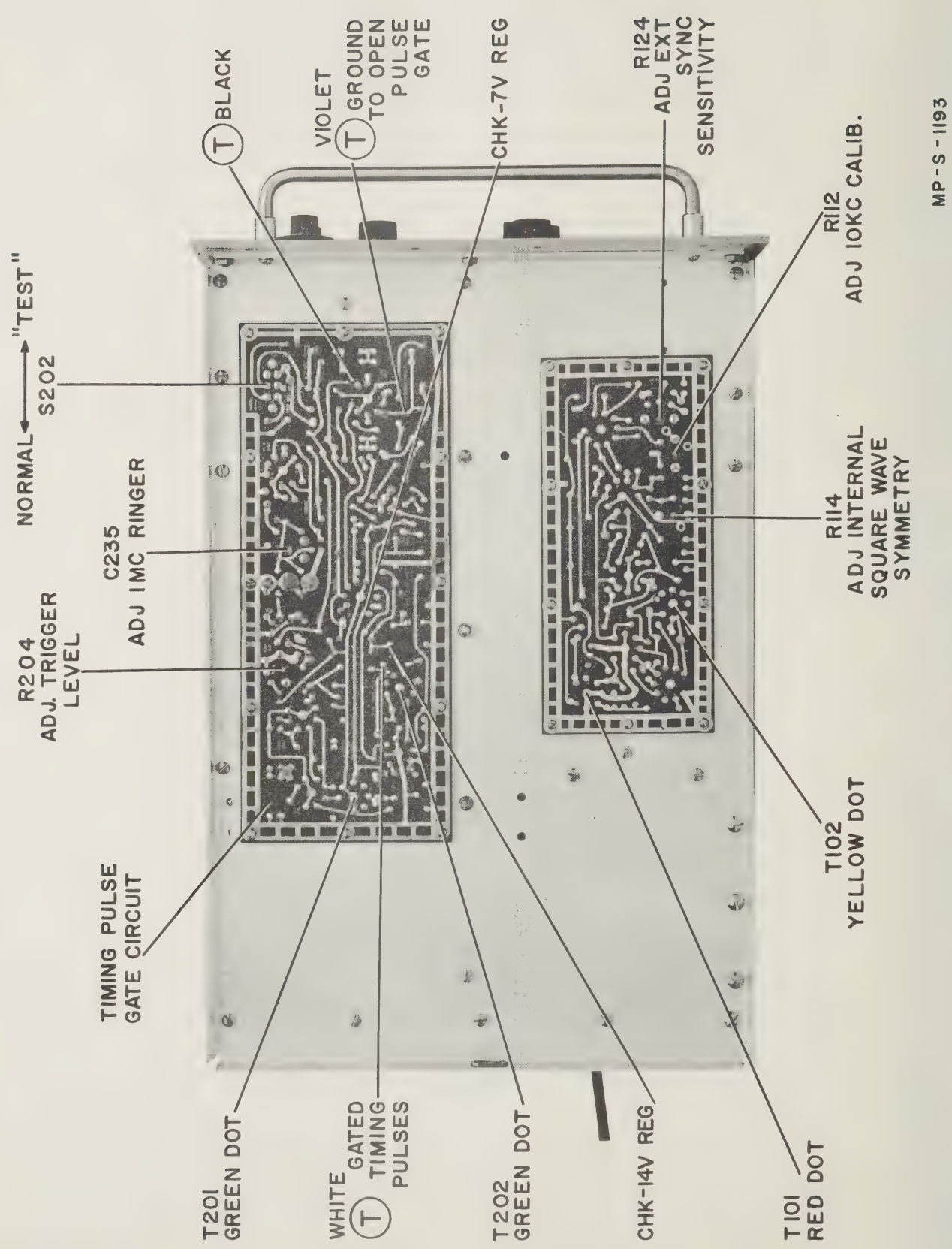


Figure 5-5. Model 218A, Left Side View

5-48. ℗ test equipment required: High-Frequency Oscilloscope, Model 150A or equivalent, and Model 152B Dual Trace Amplifier; Electronic Counter Model 524C/D or equivalent; Oscillator, Model 200C/D or equivalent, and AC Voltmeter, Model 400D or equivalent.

5-49. ADJUSTING PULSED CRYSTAL OSCILLATOR.

5-50. Before making any adjustments in the pulsed crystal oscillator section, be sure that the trouble is within this section.

5-51. It is important that adjustments are made in the sequence given in table 5-5. The pictures show the actual waveforms as they were observed while making the adjustments. The arrow mark points to the waveform obtained with the proper adjustment or tuning.

5-52. To adjust the frequency (start phase) and amplitude of the pulsed crystal oscillator, refer to figures 5-5 and 5-6.

5-53. ℗ test equipment required: High-Frequency Oscilloscope Model 150A or equivalent; Model 151A High Gain Amplifier; Model 152B Dual Trace Amplifier and 10:1 division AC21A High Impedance Probe.

5-54. ADJUSTING DECADE TUBE BIAS.

5-55. The bias voltage of the type 6700 decade tubes needs readjustment:

a. If a type 6700 decade tube has been replaced.

b. If counter section is not operating properly (decades do not divide by "10").

Note

Table 5-6A is to be used only if Model 218A is not operating. It is a rough adjustment and relies only on the pulsed crystal oscillator and gate section and the counter circuit. Table 5-6B is a final adjustment and must be used only when Model 218A is operating.

5-56. For the location of testpoints and adjustment controls refer to figure 5-7.

CAUTION

Turn off instrument before removing the decade plug-in drawer.

5-57. ADJUSTING THE INTERPOLATION MULTIVIBRATOR.

5-58. Having completed all previous adjustments, the overall time delay of the Model 218A is calibrated by adjusting the interpolation multivibrator. The location of the testpoints and adjustment controls is shown in figure 5-7 and figure 5-8.

5-59. The following test equipment is required: Model 150A High Frequency Oscilloscope and Model 524C/D Electronic Counter.

5-60. The calibration is done in three steps: (see figure 5-9 through 5-11).

a. Calibration of the 1 MC crystal frequency.

b. Calibration of the expanded sweep time of oscilloscope.

c. Calibration of the Interpolation Multivibrator.

5-61. For the calibration any one of the Model 219 series plug-in units can be used, providing they are set to deliver a pulse with a sharp leading or trailing edge occuring at T_0, T_1 and T_2.

5-62. FRONT PANEL PERFORMANCE CHECK.

5-63. This paragraph describes simple tests which can be performed with the instrument in its cabinet. These tests will establish that the instrument is operating normally (see figures 5-12, 5-13 and 5-14). However this performance test is not intended to check the specifications of the Model 218A. Paragraph 5-64 indicates how to measure the overall accuracy of the instrument.

5-64. OVER-ALL ACCURACY CHECK.

5-65. For the overall accuracy check the following test equipment is required: ℗ Model 524C/D Counter or equivalent, with ℗ Model 526B Time Interval plug-in unit.

5-66. The set up for measurements is shown in figure 5-15.

5-67. PROCEDURE FOR THE OVERALL ACCURACY CHECK.

a. Counter should indicate the selected delay period of the Model 218A to: 1.5 μsec ±0.2 μsec ±0.001% of selected time delay.

Note

The error of ±0.2 μsec ±0.001% (of time delay) is the maximum allowable error and accounts for ±0.1 μsec (of Model 524C/D Counter) and ±0.1 μsec ±0.001% of selected time delay (of Model 218A Digital Delay Generator). The maximum allowable error for delay times below 5000 μsec is ±0.2 μsec, for delay times above 5000 μsec is ±0.3 μsec.

b. Switch UNITS controls of T_2 to each digit from 1 to 9. Counter should indicate time delay ±0.2 μsec maximum. If error exceeds ±0.2 μsec see below.

c. Repeat step 2 for TENS, HUNDREDS and THOUSANDS controls of T_2. Counter reading should stay within ±0.2 μsec for time delays less than 5000 μsec and ±0.3 μsec for time delays of 5000 μsec and above.

d. If error exceeds ±0.2 μsec (or ±0.3 μsec for 5000 μsec and above) see paragraph 5-68.

Table 5-5. Adjusting Pulsed Crystal Oscillator

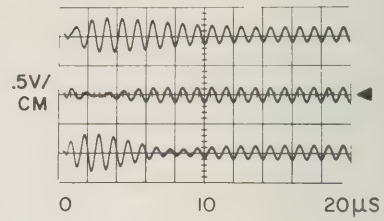
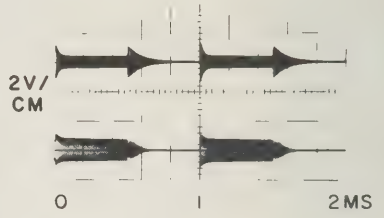
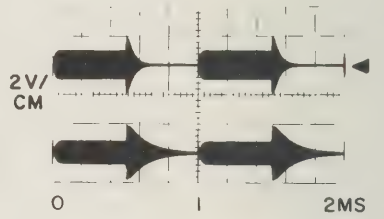
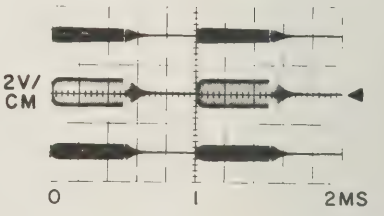
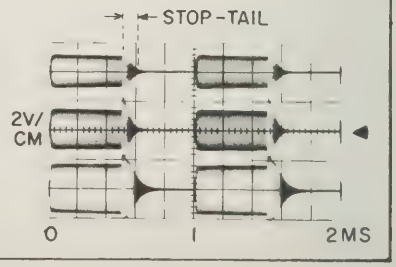
218A Settings	Oscilloscope Settings	Adjust/Check	Waveforms
1. BRIDGE BALANCE			
Switch S202 in TEST Set Pulse repetition rate to 2 kc. INPUT AC-coupled	Sweep: 2 μsec/1 cm Sync: + EXT pin 7 of V204 Probe: pin 1 of V209 Vert. Sens: .05 v/cm	Adjust C216 for minimum or zero within first 3-4 cycles (first few cycles of crystal oscillation are not used).	
2. OSCILLATOR TUNING			
Same setting as in 1. L205 tuned for minimum	Sweep: 200 μsec/cm Sync: + EXT pin 7 of V204 Probe: pin 5 of V209 Vert. Sens: 2 v/cm	Turn slug of L204 in a few turns. Turn slowly ccw. 1 mc signal passes thru broad relative maximum, before breaking into violent oscillation.	
		Tune L204 for relative maximum (appr. 1 turn from position causing violent oscillation). Lock L204 adjustment.	
3. 1 MC LIMITER			
Same setting as in 1.	Same setting as in 2.	Tune L206 for maximum	
4. 1 MC AMPLIFIER			G-L-142
Same setting as in 1.	Same setting as in 2. Vert. Sens: .2 v/cm	Tune L205 for maximum amplitude and with minimum stop-tail. Lock L205 adjustment. Retune L206. Lock L206 adjustment.	

Table 5-5. Adjusting Pulsed Crystal Oscillator (Cont'd)

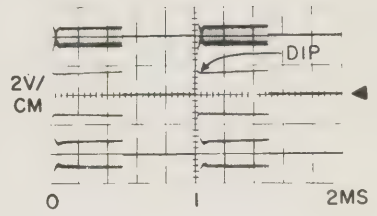
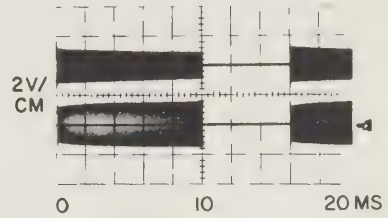
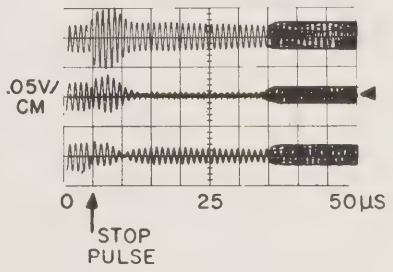
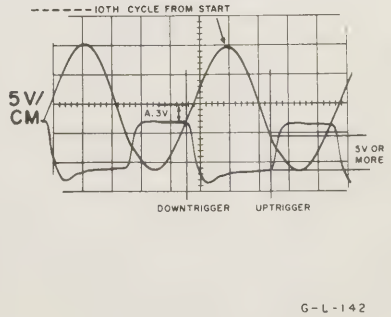
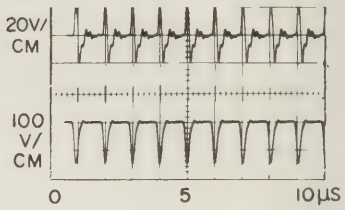
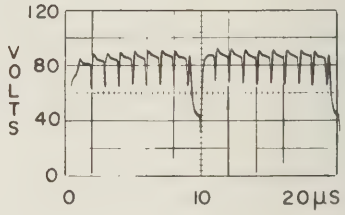
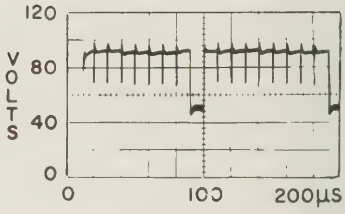
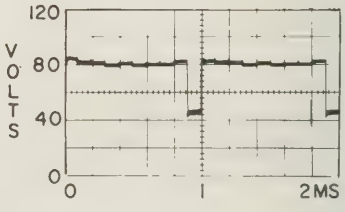
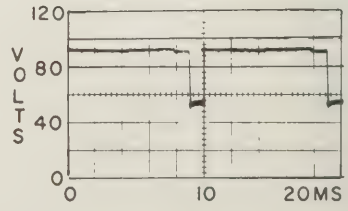
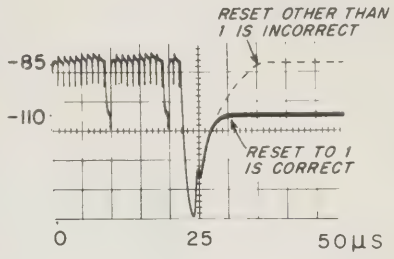
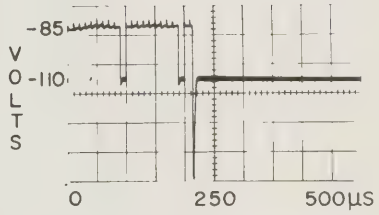
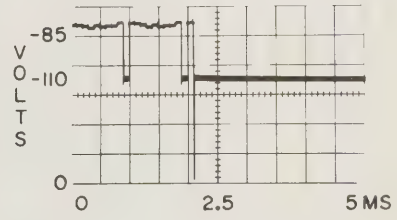
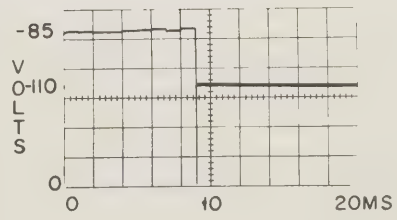
218A Settings	Oscilloscope Setting	Adjust/Check	Waveforms
5. 1 MC RINGER			
Switch S202 in TEST. Set pulse repetition rate to 1000 cps	Sweep: 200 μsec/cm Sync: + EXT pin 7 of V204 or TP Vert. Sens: .2 v/cm Probe: pin 7 of V201	Retune L206, lock L206 adjustment. Adjust C235 for maximum amplitude and minimum dip.	
6. FEEDBACK ADJUST			
Set switch S202 to NORMAL. Set T_1 and T_2 to 10,000 μsec. Set pulse repetition rate to 70 cps	Sweep: 2 ms/cm Sync: + EXT use SYNC out at T_0 Probe: pin 7 of V201 Vert. Sens: 2 v/cm	Adjust C213 for appr. 25% amplitude increase from start to stop of pattern. Switch repetition rate to 5 kc, 50 cps and check that oscillator is pulsed (if necessary increase C213)	
7. STOP PHASE ADJUST			
Set switch S202 to NORMAL. Set T_1 to 60 μsec T_2 to 70 μsec Set pulse repetition rate to 8000 cps.	Sweep: 10 μsec/cm Sync: + EXT Sync out at T_1 Probe: pin 1 of V209 Vert. Sens: .005 v/cm (use high-sensitivity plug-in)	Adjust R627 (Stop Phase) Minimum signal amplitude between modulation envelopes.	
8. SCHMITT TRIGGER CHECK			
Same setting as in 7 with exception of COUNTED FREQ. to EXT. 100 KC, 0.4 V RMS to COUNTED FREQ. INPUT	Sweep: 2 μsec X10 Sync: EXT AC EXT + SYNC to pin 7 V204 Probe A: pin 2, V201 Probe B: Junction of R211 and R246 Vert. Sens.: 05v/cm	Locate start of sinewave with oscilloscope horizontal position control. Place start of sinewave on horizontal axis with vertical control. Move display ten cycles to left with horizontal control. Adjust R204 until square-wave down-triggering occurs at a point on sinewave 3 volts below axis as shown in waveform. Up-triggering should occur at a time where the sinewave is 5 volts or more above its negative peak as shown in waveform.	
For operation, check of preset gate and reset circuit see paragraph 5-25, Waveforms.			

Table 5-6A. Adjusting Decade Counter Bias (218A NOT operating)

218A Settings	Oscilloscope Setting	Adjust/Check	Waveforms
1. 1 MC TIMING PULSE CHECK			
Switch S202 to TEST Short pin 6 of V206 to ground	Sweep: 1 μsec/cm Sync: INT Oscilloscope Probe: A. Pink wire at test point of R306 and C302 B. Test point pin 3 of T202	Check 1 MC timing pulses	
2. UNITS/DECADE BIAS			
Same as 1	Sweep: 2 μsec/cm Oscilloscope Probe: Brown wire of S301 (UNITS) DC Probe: Junction of R304 and R306	Adjust R304 to center of range where it correctly divides by 10	
3. TENS DECADE BIAS			
Same as 1	Sweep: 20 μsec/cm Oscilloscope Probe: Black wire of S302 (TENS) DC Probe: Junction of R340 and R342	Adjust R340 Same as 2	
4. HUNDREDS DECADE BIAS			
Same as 1	Sweep: 200 μsec/cm Oscilloscope Probe: Black wire of S303 (HUNDREDS) DC Probe: Junction of R373 and R376	Adjust R376 Same as 2	
5. THOUSANDS DECADE BIAS			
Same as 1 Pull Reset Blocking Oscillator Tube V603 (Turn off instrument before replacing V603)	Sweep: 2 ms/cm Oscilloscope Probe: Black wire of S304 DC Probe: Junction of R415 and R417	Adjust 415 Same as 2	

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Table 5-6B. Adjusting Decade Counter Bias (218 Operating)

218A Setting	Oscilloscope Setting	Adjust/Check	Waveforms
1. UNITS DECADE			
Switch S202 to NORMAL Set T_1 and T_2 to 0022.0 μsec	Sweep: 5 μsec/cm Sync: SYNC OUT to T_0 Probe: Brown wire S301 (Unit) Vert. Sens: 10 v/cm Input - DC	Voltmeter - 300 range Voltmeter to center tap R304 Turn R304 counterclockwise until waveform dip becomes unstable. Record reading. Turn R304 clockwise until waveform becomes unstable. Record reading. Take sum of the two and divide by 2. Set R304 to that voltage Note: Decade must be dividing by 10.	
2. TENS DECADE			
Switch S202 to NORMAL Set T_1 and T_2 to 0222.0 μsec Set pulse repetition rate to 100 cps	Sweep: 50 μsec Sync: SYNC OUT T_0 Probe: Black wire S302 (TENS) Vert. Sens: 10 v/cm Input - DC	Adjust R340 Same as 1	
3. HUNDREDS DECADE			
Switch S202 to NORMAL Set T_1 and T_2 to 2222.0 μsec Set pulse repetition rate to 100 cps	Sweep: .5 ms/cm Sync: SYNC OUT to T_0 Probe: Black wire S303 (HUNDREDS) Vert Sens: 10 v/cm Input - DC	Adjust R376 Same as 1	
4. THOUSANDS DECADE			
Switch S202 to NORMAL Set T_1 and T_2 to 0000.0 μsec Set pulse repetition rate to 25 cps	Sweep: 2 ms/cm Sync: SYNC OUT to T_0 Probe: Black wire S304 (THOUSANDS) Vert. Sens: 10 v/cm Input - DC	Adjust R415 Same as 1	

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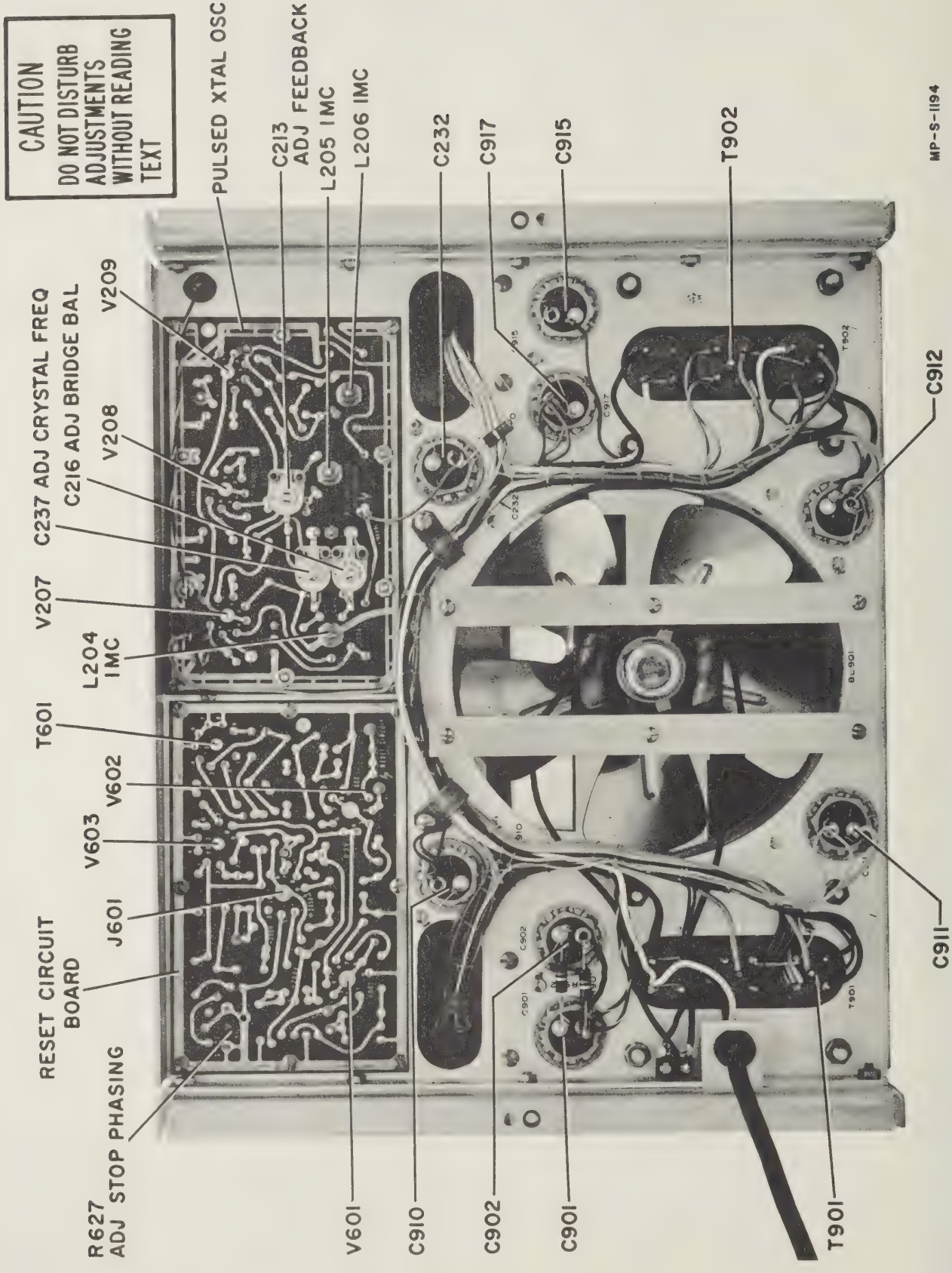


Figure 5-6. Model 218A, Rear View

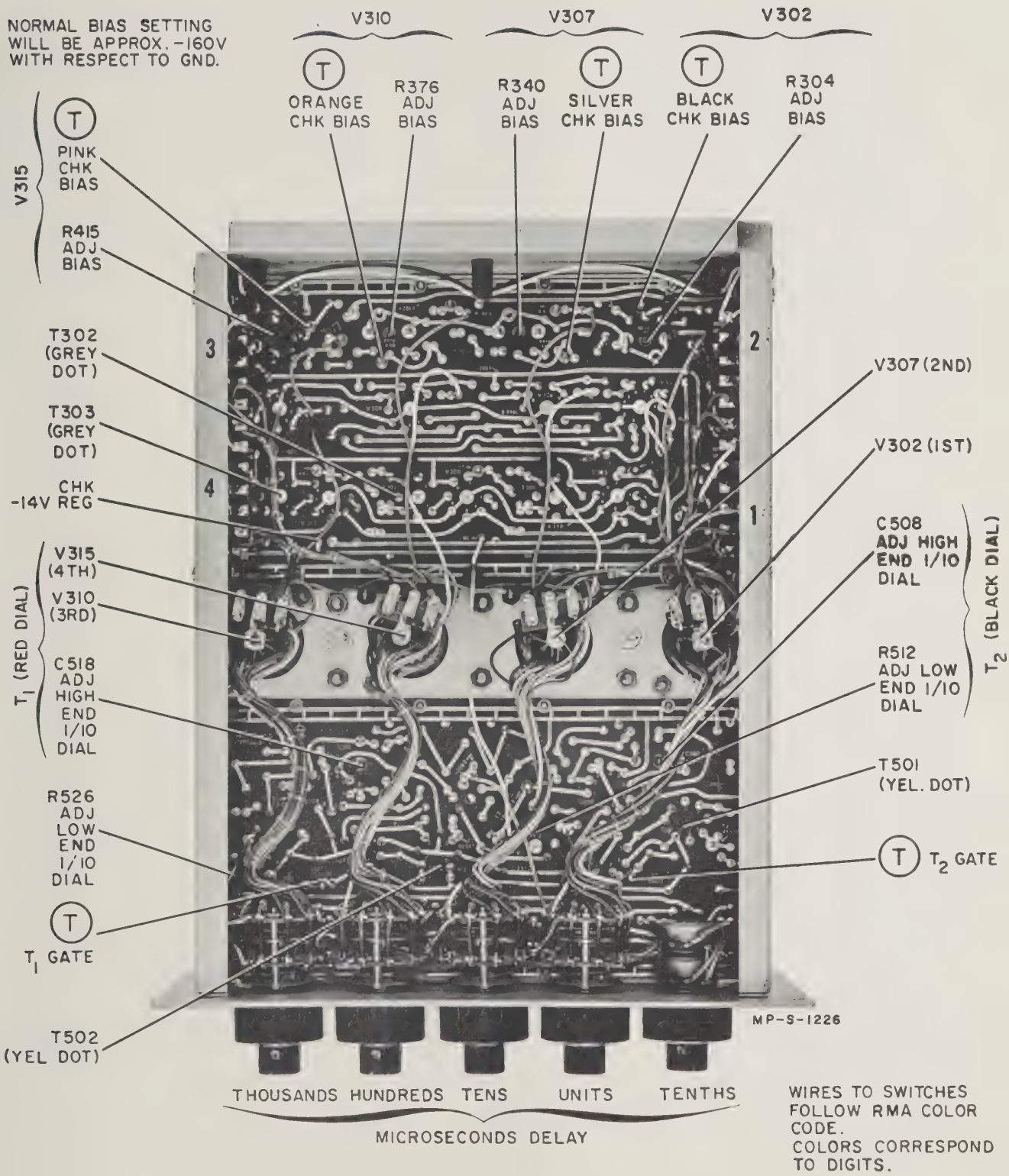


Figure 5-7. Delay Unit Top View

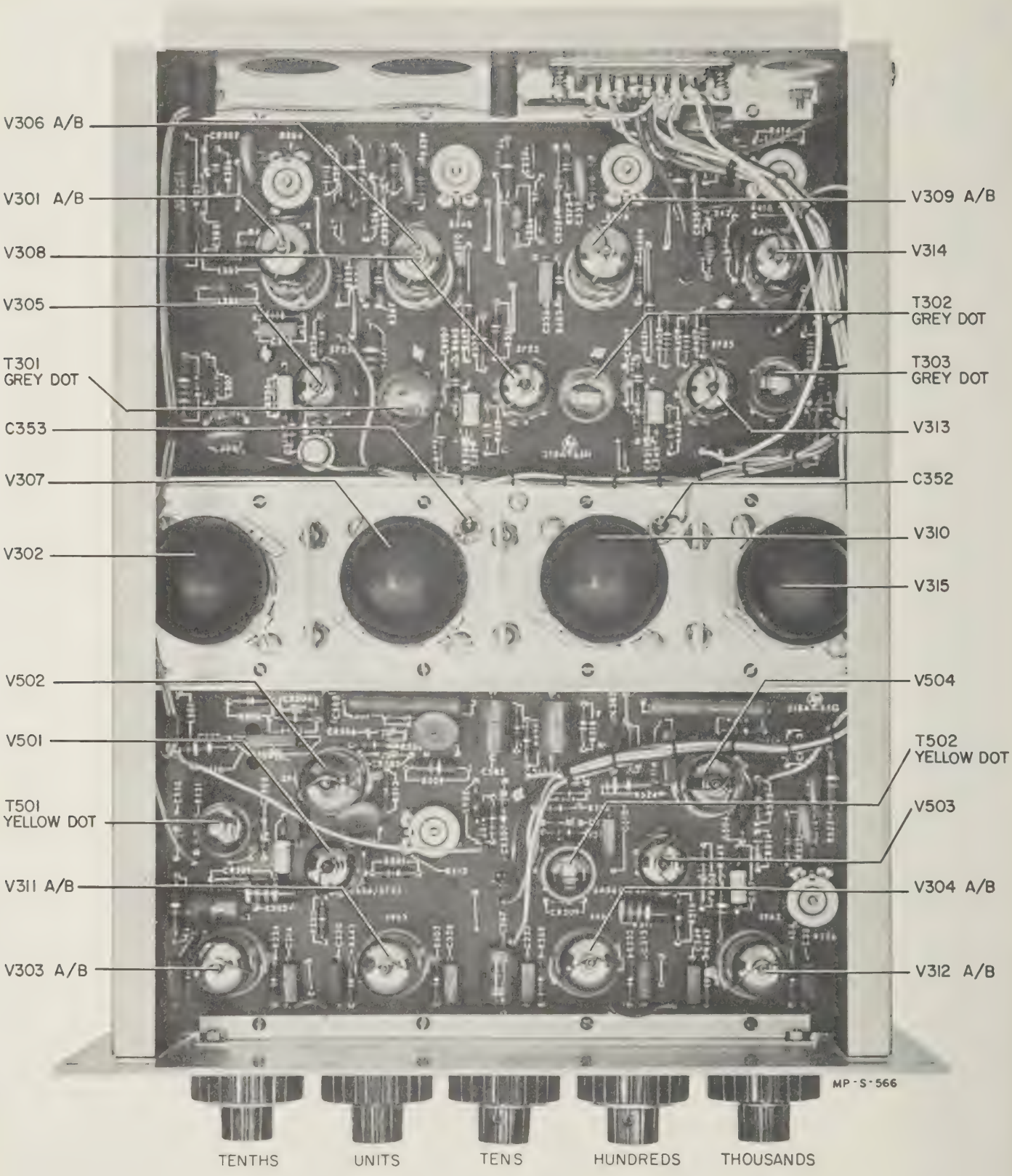
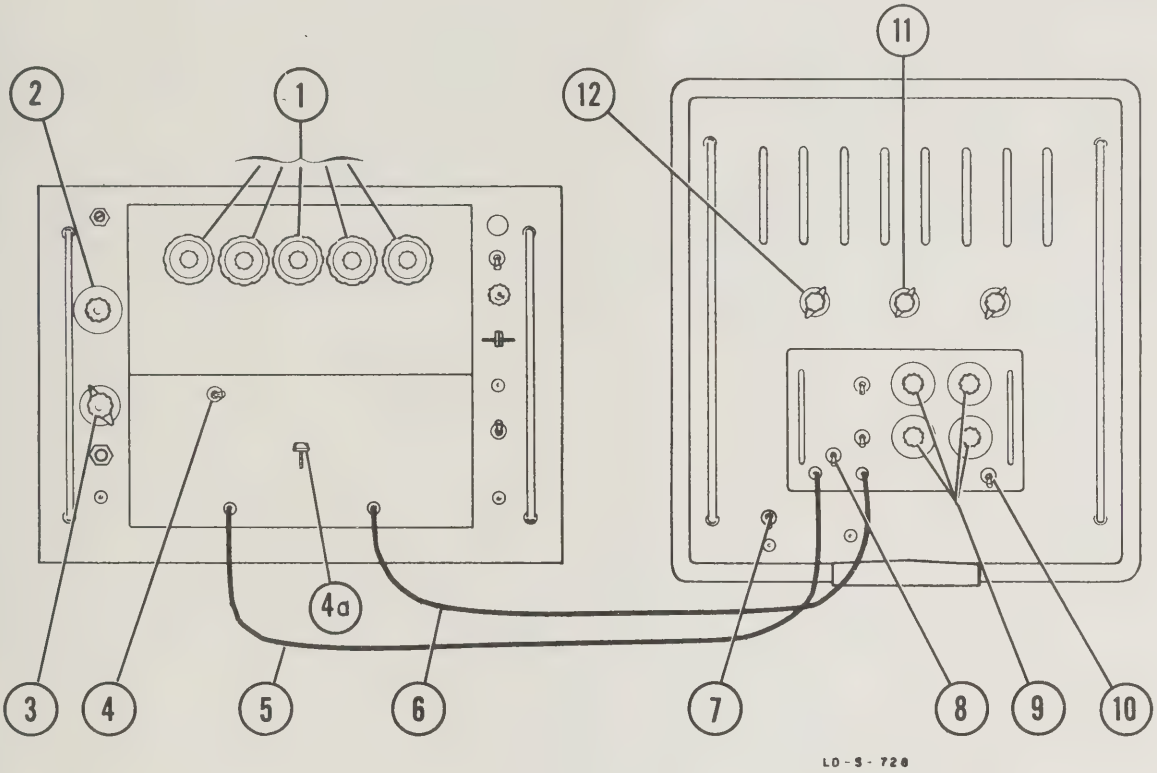


Figure 5-8. Delay Unit, Bottom View



1. Set T_1 to 0001.5, switch T_2 from 1000.5 μSEC DELAY to 10,000.5 μSEC DELAY. (Dial setting 0000.5)
2. Set PULSE RATE to 50.
3. Set START PULSE SELECTOR to X1.
4. Set switch to T_0; switch to SEP
5. Connect Output of Pulse A to START INPUT. Pulse A: Amp +30V, width 1 μsec
6. Connect Output of Pulse B to STOP INPUT. Pulse B: Amp +30V width 1 μsec.
7. Switch to INTERNAL.
8. Switch to SEP.
9. SET TRIGGER LEVEL VOLTS TO (2x) (+4) volts (START - and STOP PULSE).
10. Switch to TIME INTERVAL.
11. Set FUNCTION SELECTOR to PERIOD.
12. Set STD. FREQ. COUNTED to 10 MC.

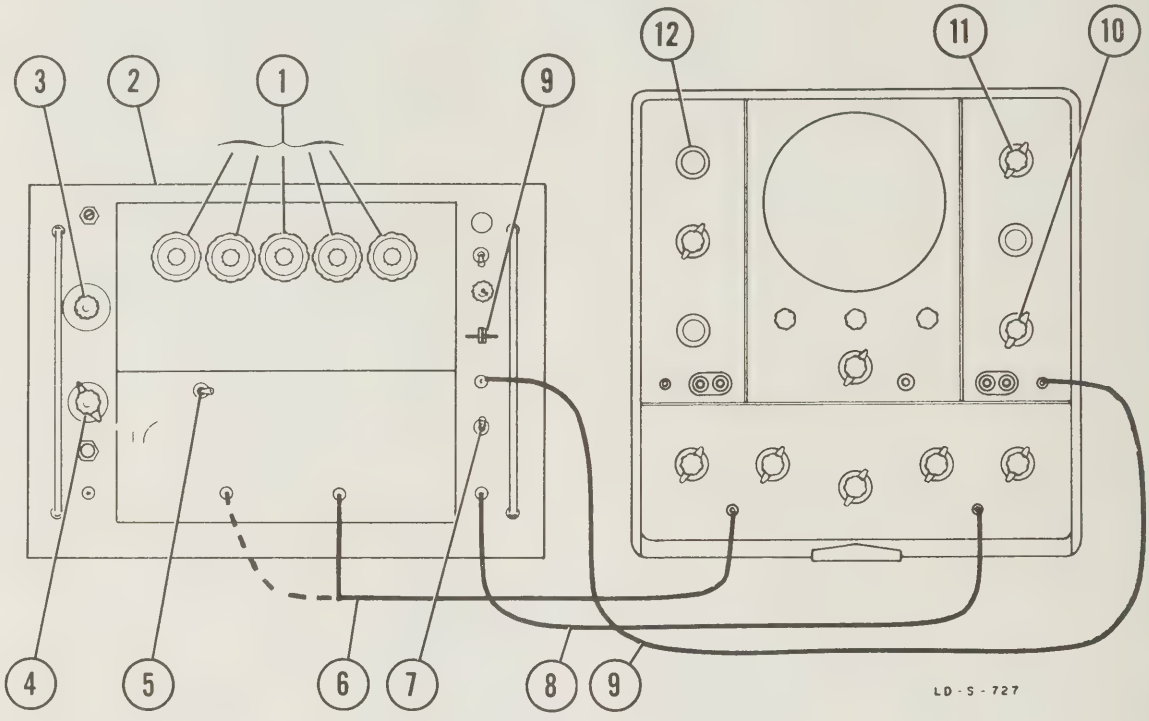
CHECK:

Crystal Frequency correct if difference between the two readings is 9000 ±0.2 μsec.

Crystal Frequency is high, if difference between the two readings is low. Increase capacity of C237.

Crystal Frequency is low, if difference between the two readings is high. Decrease capacity of C237. If Xtal frequency is changed appreciably Xtal bridge balance C216 will also require adjustment. Recheck Xtal frequency after balancing. See table 5-5, step 1.

Figure 5-9. Calibration of the 1 MC Crystal Frequency



1. Set T_1 and T_2 to 100 μsec.
2. Set Switch S202 to NORMAL.
3. Set PULSE RATE to 50.
4. Set START PULSE SELECTOR TO X100.
5. Switch to T_0.
6. Connect Pulse B output to INPUT A.
7. Switch to INT. 1 MC.
8. Connect COUNTED FREQ. Output to INPUT B.
9. Connect SYNC. OUTPUT of 218A to EXT. SYNC. INPUT. Set SYNC. SELECTOR of 218A to T_0.
10. Set TRIGGER SLOPE TO +.
11. Set SWEEP TIME to 10 μsec/cm.
12. Set EXPAND control to X50 (HORIZONTAL SENSITIVITY).

Procedure:

- Switch VERTICAL PRESENTATION control to INPUT B.
- Move 1 MC pattern with HORIZONTAL POSITION control to the right, so last 1 MC pulse appears on the right hand side of the screen.
- Calibrate expanded sweep with VERNIER of SWEEP TIME control, so adjacent 1 MC pulses are 5cm ±0.1 cm apart.

Figure 5-10. Calibration of Expanded Oscilloscope Sweep Time

Use arrangement of figure 5-4 with the following alterations:

a. Set T_1 to 1 μsec., and T_2 to 2.0 μsec.

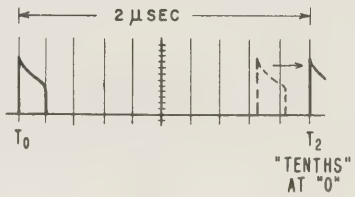
b. Connect SYNC. OUTPUT of 218A to INPUT B and to EXT. SYNC of oscilloscope (SYNC on T_0).

c. Switch VERTICAL PRESENTATION to ALTERNATE.

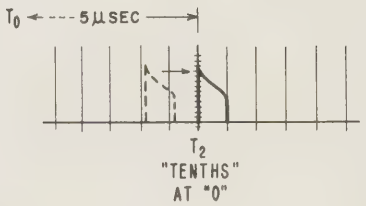
d. When using 219A or 219B: Set Switch (5) for PULSE A at T_1 When using 219C: Set PULSE TIMING switch to T_1 - T_2.

Procedure:

1. Set "TENTHS" control of T_1 and T_2 to "0".
2. Align T_0 pulse with graticule line (use HORIZONTAL POSITION control).
3. Align T_2 pulse with R512 (ADJ. LOW END 1/10 DIAL) so T_2 occurs 2.0 μsec. after T_0.
 Accuracy: 2.0 μsec. = 10 cm ±0.1 cm.

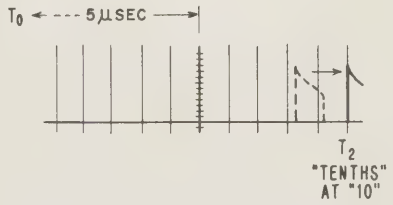


4. Switch "UNITS" control to T_2 to 5 μsec.
 Set T_2 pulse on center line of graticule with HORIZONTAL POSITION control of oscilloscope.
5. Set "TENTHS" dial of T_2 to "10".
 Adjust C508 (ADJ. HIGH END 1/10 DIAL) so T_2 coincides with vertical line of graticule (5cm to the right of center line)



6. Set "TENTHS" dial of T_2 to "0".
 Adjust R512 (ADJ. LOW END 1/10 DIAL) so T_2 coincides with center line of graticule.

 Repeat steps 5 and 6 until both settings are within 0.2 cm.

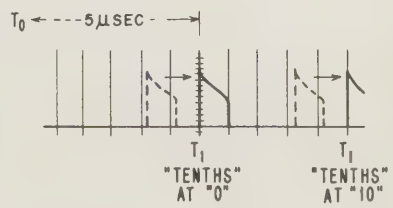


7. Set T_2 to 2.0 μsec.
 Set T_1 to 5.0 μsec.

 DO NOT CHANGE SETTING OF HORIZONTAL POSITION CONTROL OF OSCILLOSCOPE.

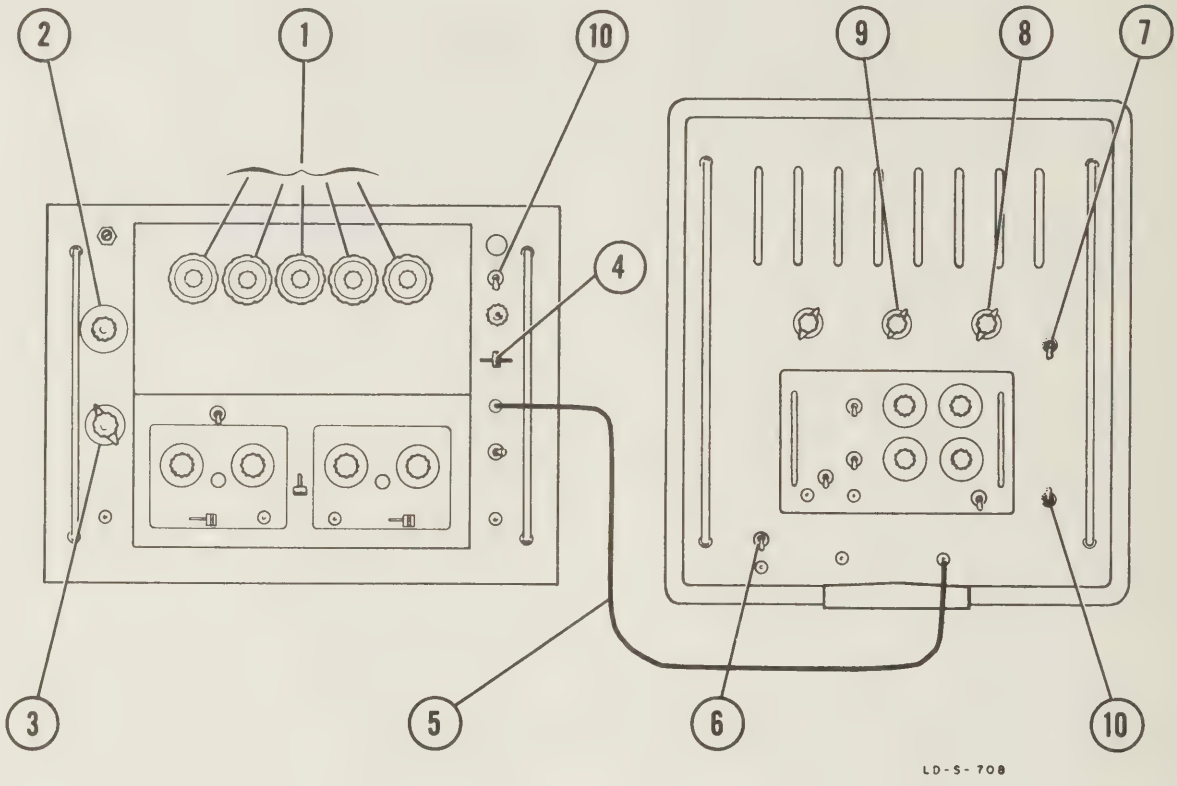
8. Connect Output of Pulse A to INPUT A of oscilloscope. Repeat step 5 and 6 for pulse T_1 without changing the setting of the HORIZONTAL POSITION control of the oscilloscope.

 Adjust R526 (ADJ. LOW END 1/10 DIAL) with "TENTHS" control of T_1 at "0".
 Adjust C518 (ADJ. HIGH END 1/10 DIAL) with "TENTHS" control of T_1 at "10".



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Figure 5-11. Calibration of the Interpolation Multivibrator



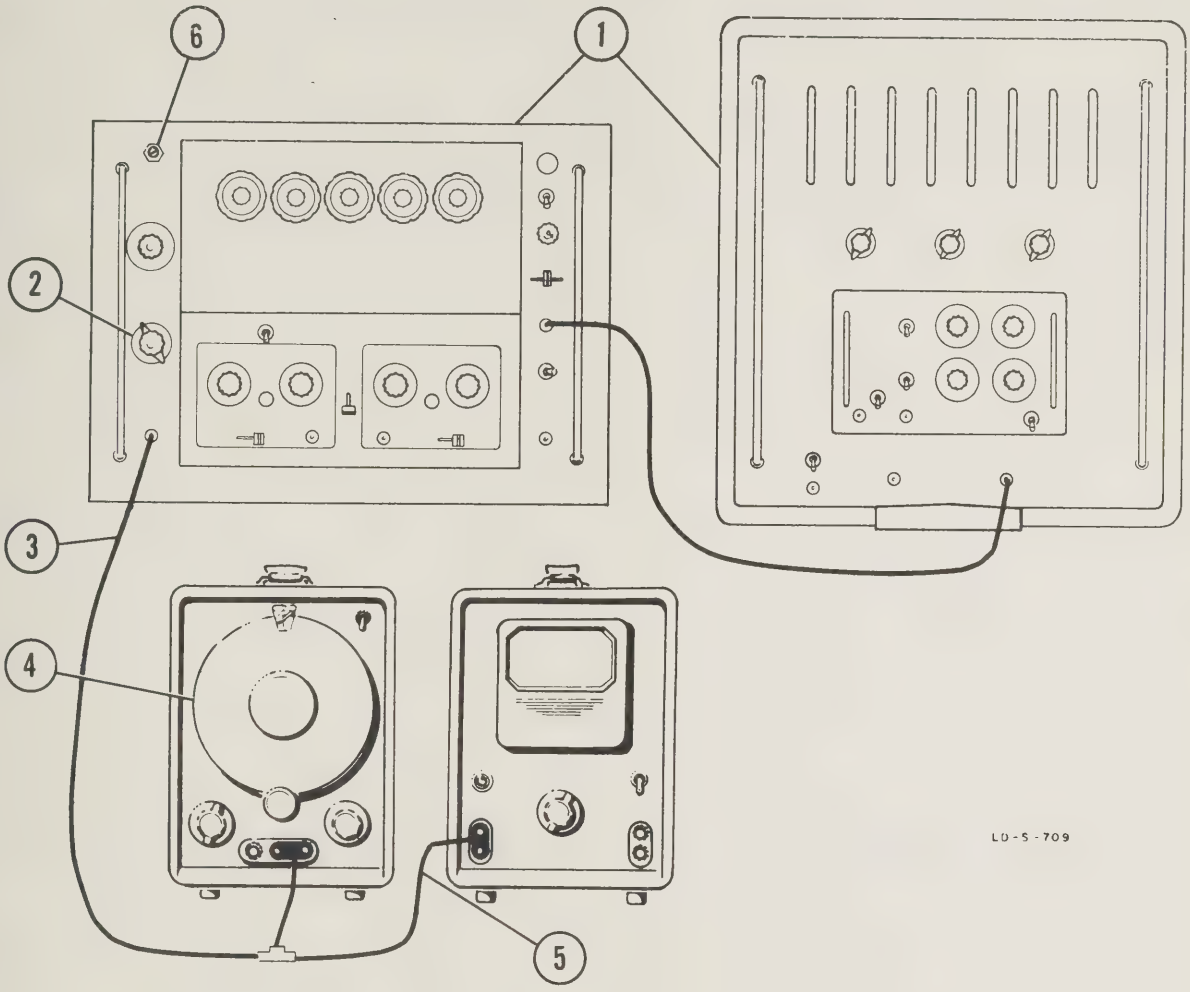
1. Set both MICROSECOND DELAY dials T_1 and T_2 to 0001.5.
2. Set PULSE RATE to 100.
3. Set START PULSE SELECTOR to X100.
4. Set SYNC OUT selector to T_0.
5. Connect SYNC OUTPUT of Model 218A to SIGNAL INPUT of 524C/D.
6. Set 100 KC STANDARD to INT.
7. Set MANUAL GATE switch to CLOSED.
8. Set STD. GATE TIME switch to 1.
9. Set FUNCTION SELECTOR to FREQUENCY.
10. Turn ON both instruments.

CHECK -

a) Counter should indicate 10,000 cps ±10% nominally.

b) Set SYNC OUTPUT switch to T_1 (and T_2) counter reading 10,000 cps for switch in T_1 and T_2.

Figure 5-12. Check Input Repetition Rate



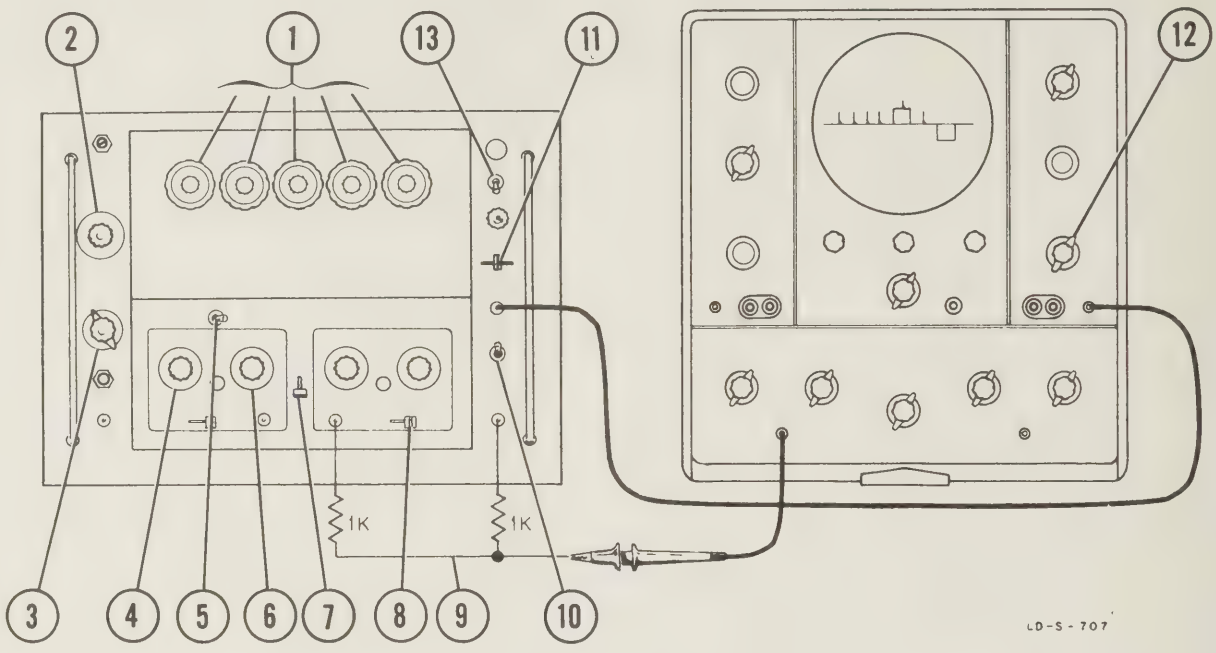
1. Use set-up as shown in Figure 5-12.
2. Set START PULSE SELECTOR to + EXT.
3. Connect output of Model 200C/D to EXT. TRIGGER Input of Model 218A.
4. Set FREQUENCY of Model 200C/D to 1 KC.
5. Monitor output of Model 200C/D with AC Voltmeter, Model 400D.

CHECK -

a) Turn TRIGGER LEVEL control (6) fully clockwise. Amplitude of trigger signal approximately 1.5 volts rms for stable operation of 218A (check reading on counter).

b) Turn TRIGGER LEVEL control (6) fully counterclockwise. Amplitude of trigger signal approximately 10 volts rms for stable operation of Model 218A.

Figure 5-13. Check Input Sensitivity



1. Set MICROSECOND DELAY dial T_1 to 0004.5 μsec and T_2 to 0006.5 μsec.
2. Set PULSE RATE to 50.
3. Set START PULSE SELECTOR to X100.
4. Set WIDTH to 1 μsec (Pulse A and B).
5. Switch to T_0.
6. Set AMPLITUDE to 5 volts (Pulse A and B).
7. Switch to COM.
8. Select POSITIVE Pulse A and NEGATIVE Pulse B.
9. Connect Oscilloscope Probe to output Pulse B of Model 219B plug-in unit and to INT. 1 mc of Model 218A as shown. (Use composition resistor.)
10. Switch to INT. 1 mc.
11. Set SYNC OUTPUT selector to T_0.
12. Synchronize oscilloscope on + EXT.
 Sweep: 10 μsec/cm
 Vert: 5V/cm
13. Turn ON instrument.

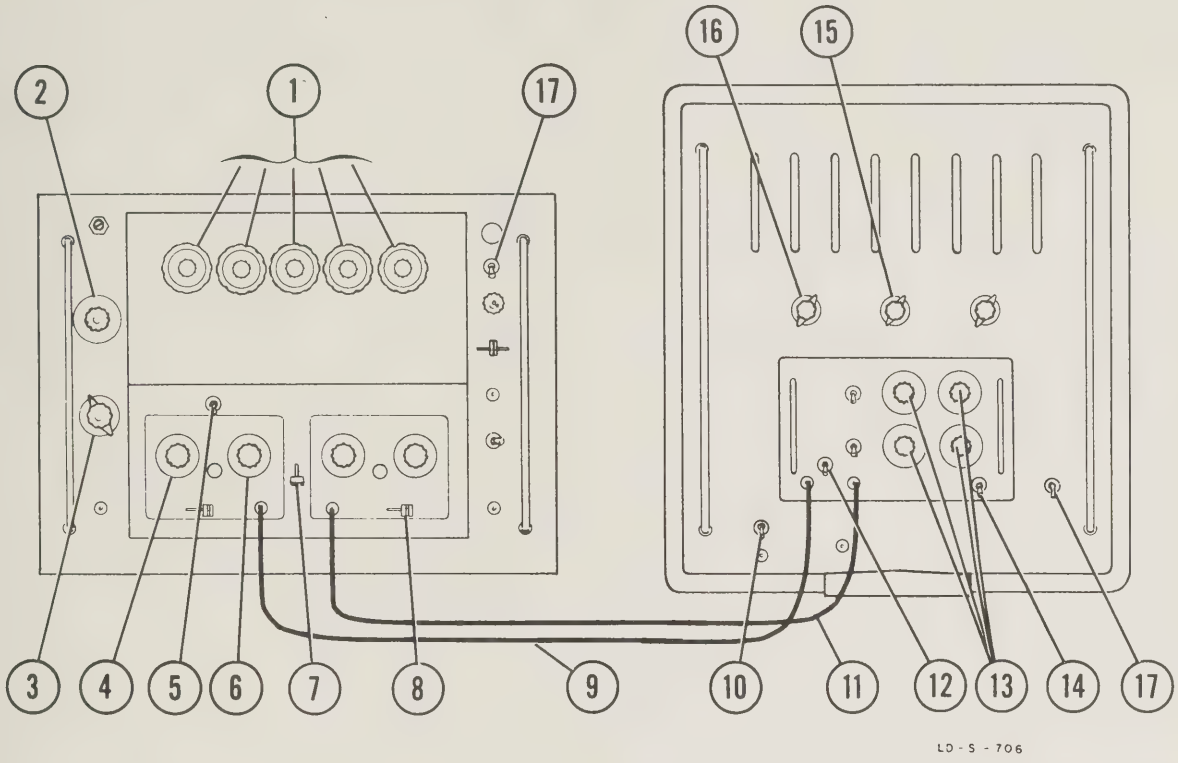
CHECK-

a) Compare pattern on Oscilloscope with pattern shown.

b) Check relative position of Output Pulse and 1 mc timing pulses, as you change setting of TENTHS dial.

c) Timing pulses are stopped when longer delay period (T_1 or T_2) has elapsed.

Figure 5-14. Check Timing Pulses and Preset Gate



1. Set MICROSECOND DELAY dials to 0001.5 μsec (T_1 and T_2).
2. Set PULSE RATE to 50.
3. Set START PULSE SELECTOR to X1.
4. Set WIDTH to 1 μsec (Pulse A and B).
5. Switch to T_0.
6. Set AMPLITUDE to +50 volts (Pulse A and B).
7. Switch to SEP.
8. Switch POLARITY to + (Pulse A and B).
9. Connect Output of Pulse A to START INPUT.
10. Switch to INTERNAL.
11. Connect Output of Pulse B to STOP INPUT.
12. Switch to SEP.
13. Set TRIGGER LEVEL VOLTS to (2x) + 4 (Pulse A and B).
14. Switch to TIME INTERVAL.
15. Set FUNCTION SELECTOR to PERIOD.
16. Set STD. FREQ. COUNTED to 10 MC.
17. Turn ON both instruments.

CHECK-

See paragraph 5-64, Procedure for over-all Accuracy Check.

Figure 5-15. Over-all Accuracy Check

5-68. CAUSES FOR ERRORS GREATER THAN THE MAXIMUM ALLOWABLE ERROR.

5-69. If the accuracy ±0.2 μsec (or +0.3) μsec for 5000 μsec and above) is not obtained, there can be four major causes for an error:

a. Misadjustment of Interpolation Multivibrator

b. 1 MC Crystal Frequency off

c. Phase adding error

d. Misadjustment of Schmitt trigger Bias (V202).

5-70. Misadjustment of the Interpolation Multivibrator. A constant error of a few tenths of a microsecond for all time delay settings indicates a misadjustment of the Interpolation multivibrator. Paragraph 5-57 indicates the correct adjustment of the Interpolation multivibrator. It is possible, however, to check the overall accuracy of the instrument by adjusting the TENTHS control temporarily so counter reads 1.5 μsec, +0.2 μsec and proceed with steps a to c of paragraph 5-67.

5-71. 1-MC Crystal Frequency off - The 1-MC Crystal Frequency is checked by comparing the reading of the counter for two delay time settings(1000.5 μsec and 10,000.5 μsec). Proceed as follows:

a. Set Delay T_1 to 0001.5 μsec.

b. Set Delay T_2 to 1000.5 μsec. Record reading of counter.

c. Set Delay T_2 to 0000.5 μsec. Record reading of counter.

5-72. The 1-MC Crystal Frequency is correct, if the two readings are within specifications and the difference between the two readings is 9000.0 μsec ±0.3 μsec.

5-73. If the difference between the two counter readings is 9000 ±0.3 μsec but the absolute readings are high, see below: Phase Adding Error (c) or Misadjustment of Schmitt Trigger Bias (d).

5-74. If the difference between the two counter readings is not 9000 ±0.3 μsec the 1-MC crystal frequency is off. For the adjustment of the 1-MC crystal frequency see paragraph 5-57.

5-75. Phase Adding Error - A phasing error in the addition of the 1-MC ringing voltage and the 1-MC Crystal controlled voltage exists when delays above 50 μsec show a constant error of a few tenths of a microsecond. Proceed as follows:

a. Set Delay T_1 to 0001.5 μsec.

b. Set Delay T_2 to 0011.5 μsec. Record error between dial setting and counter reading.

c. Set Delay T_2 to 0111.5 μsec. Record error between dial setting and counter readings.

d. Set Delay T_2 to 1111.5 μsec. Record error between dial setting and counter reading.

5-76. If the errors in the two longest delays are equal and exceed +0.2 μsec there is a phase addition error. Check the adjustment of the 1 MC Ringer (compare waveform pattern). Check adjustment of L204.

5-77. Misadjustment of 1 MC-Schmitt Trigger Bias (V202). - Errors in delay time occur if the bias level of the Schmitt Trigger V202 is not adjusted properly. Figure 5-16 shows the result of a misadjusted trigger level bias of stage V202.

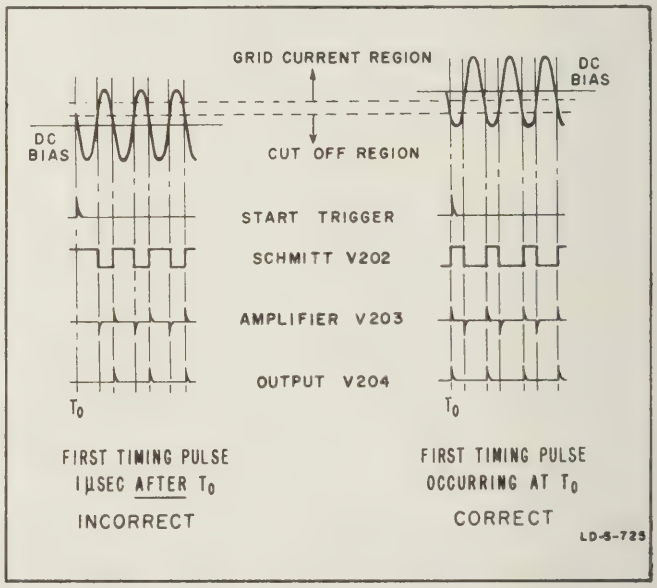
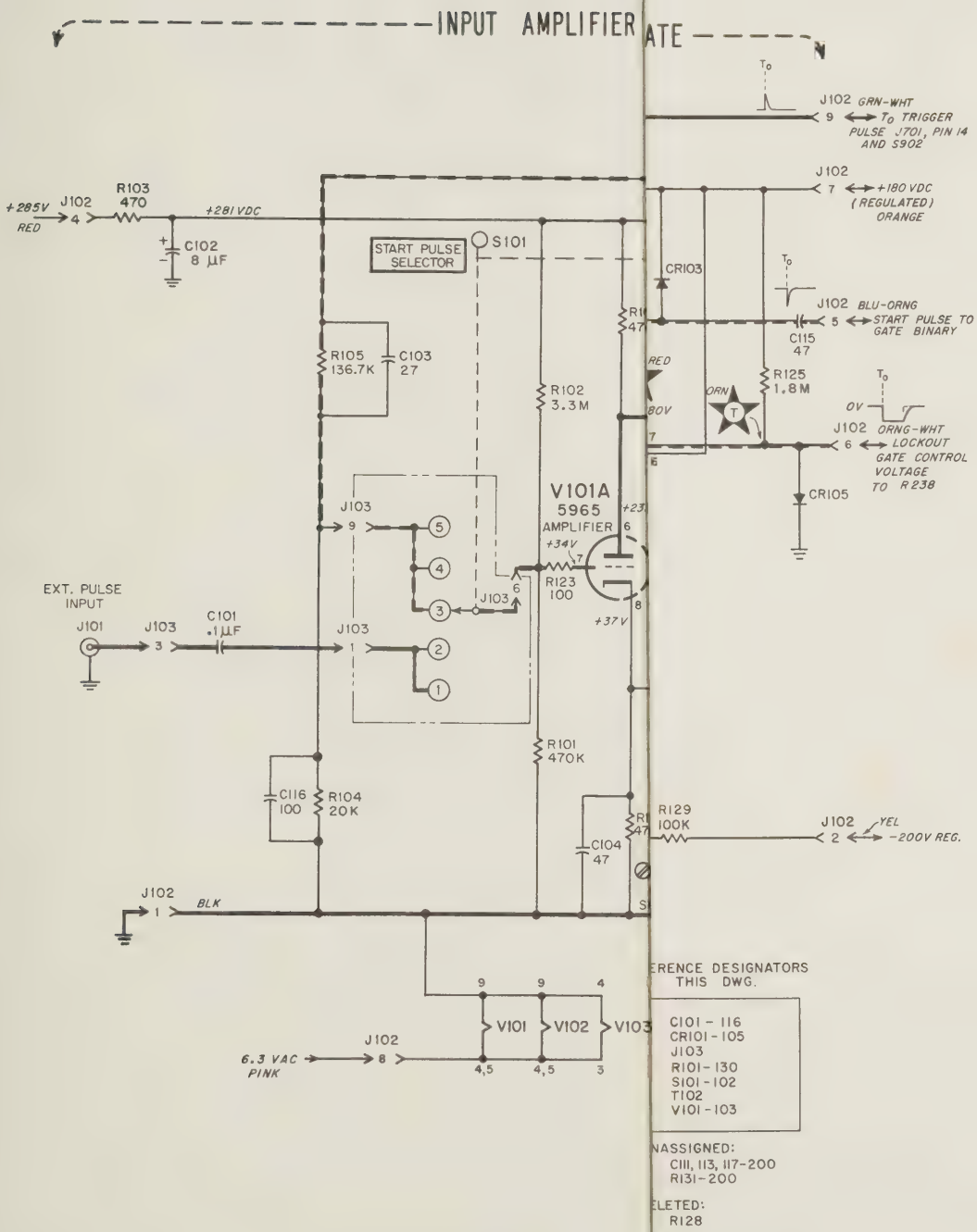


Figure 5-16. Schmitt Trigger Bias Adjustment

5-78. If the bias voltage is below cut-off when the 1-mc sine wave starts going negative, there will be no timing pulse created until 1 μsec after the 1-mc oscillation started. The error shows up when measuring the overall accuracy, since all delay times will be 1 μsec too long.



and Rate Generator Circuit

5-68. CAUSES FOR ERRORS GREATER THAN THE MAXIMUM ALLOWABLE ERROR.

5-69. If the accuracy ±0.2 μsec (or +0.3) μsec for 5000 μsec and above) is not obtained, there can be four major causes for an error:

a. Misadjustment of Interpolation Multivibrator

b. 1 MC Crystal Frequency off

c. Phase adding error

d. Misadjustment of Schmitt trigger Bias (V202).

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5-71. 1-MC Crystal Frequency off - The 1-MC Crystal Frequency is checked by comparing the reading of the counter for two delay time settings(1000.5 μsec and 10,000.5 μsec). Proceed as follows:

a. Set Delay T_1 to 0001.5 μsec.

b. Set Delay T_2 to 1000.5 μsec. Record reading of counter.

c. Set Delay T_2 to 0000.5 μsec. Record reading of counter.

5-72. The 1-MC Crystal Frequency is correct, if the two readings are within specifications and the difference between the two readings is 9000.0 μsec ±0.3 μsec.

5-73. If the difference between the two counter readings is 9000 ±0.3 μsec but the absolute readings are high, see below: Phase Adding Error (c) or Misadjustment of Schmitt Trigger Bias (d).

5-74. If the difference between the two counter readings is not 9000 ±0.3 μsec the 1-MC crystal frequency is off. For the adjustment of the 1-MC crystal frequency see paragraph 5-57.

5-75. Phase Adding Error - A phasing error in the addition of the 1-MC ringing voltage and the 1-MC Crystal controlled voltage exists when delays above 50 μsec show a constant error of a few tenths of a microsecond. Proceed as follows:

a. Set Delay T_1 to 0001.5 μsec.

b. Set Delay T_2 to 0011.5 μsec. Record error between dial setting and counter reading.

c. Set Delay T_2 to 0111.5 μsec. Record error between dial setting and counter readings.

d. Set Delay T_2 to 1111.5 μsec. Record error between dial setting and counter reading.

5-76. If the errors in the two longest delays are equal and exceed +0.2 μsec there is a phase addition error. Check the adjustment of the 1 MC Ringer (compare waveform pattern). Check adjustment of L204.

5-77. Misadjustment of 1 MC-Schmitt Trigger Bias (V202). - Errors in delay time occur if the bias level of the Schmitt Trigger V202 is not adjusted properly. Figure 5-16 shows the result of a misadjusted trigger level bias of stage V202.

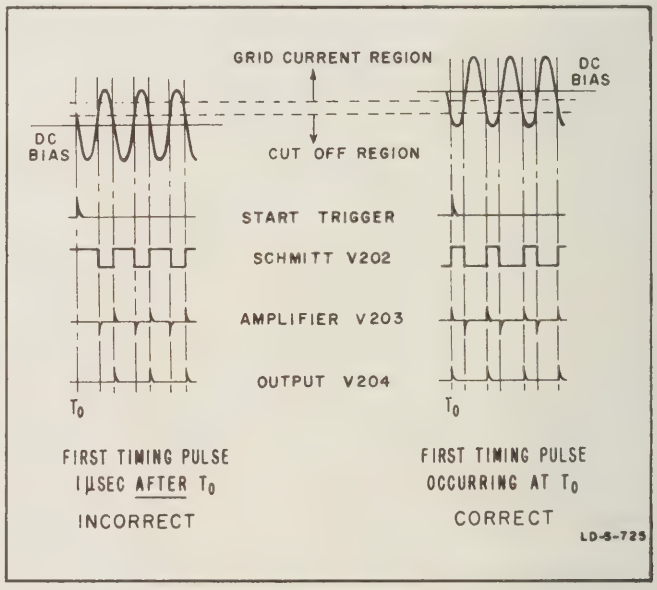
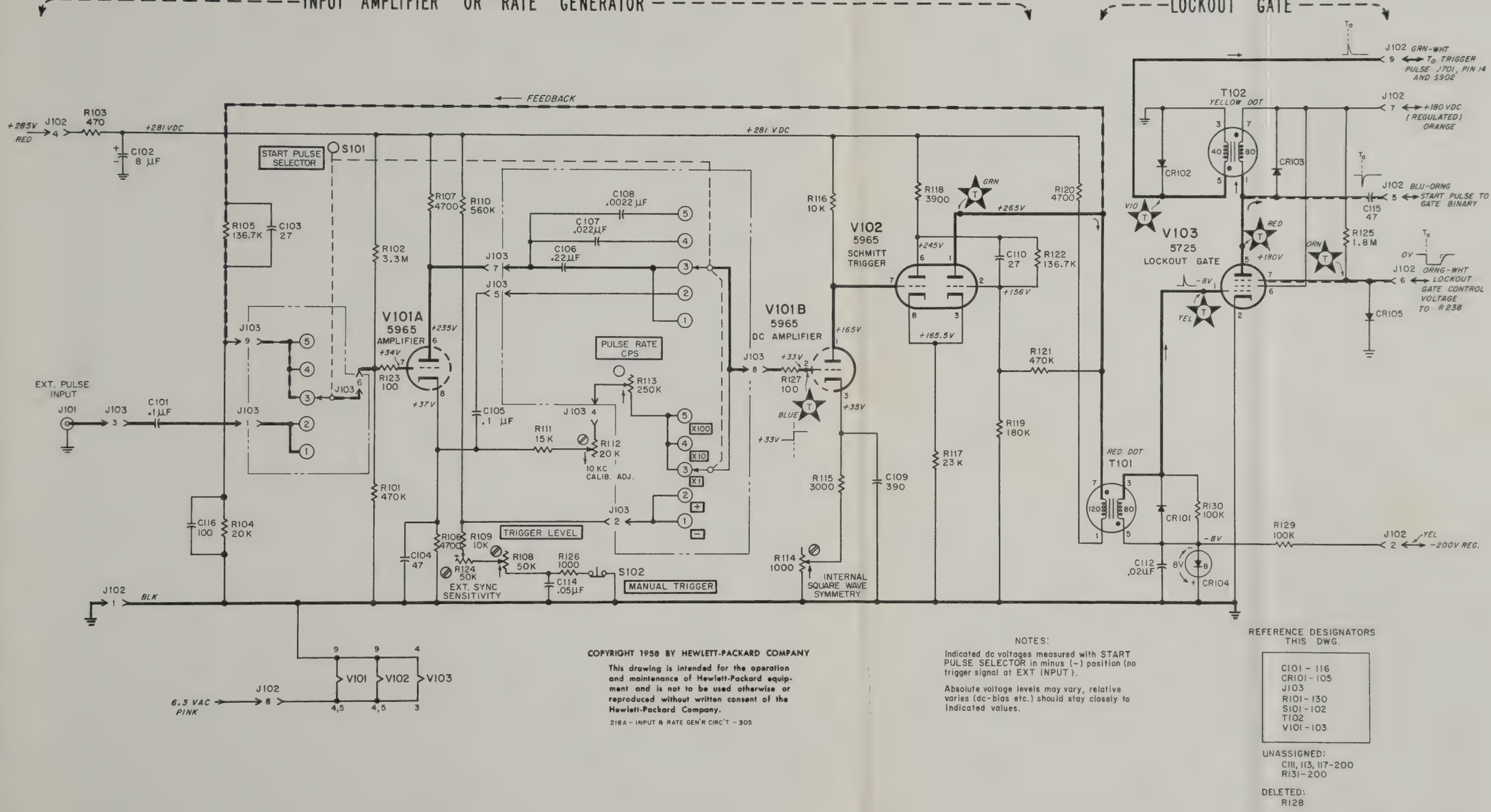


Figure 5-16. Schmitt Trigger Bias Adjustment

5-78. If the bias voltage is below cut-off when the 1-mc sine wave starts going negative, there will be no timing pulse created until 1 μsec after the 1-mc oscillation started. The error shows up when measuring the overall accuracy, since all delay times will be 1 μsec too long.



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218A – INPUT & RATE GEN'R CIRC'T – 305

NOTES:

Indicated dc voltages measured with START PULSE SELECTOR in minus (–) position (no trigger signal at EXT INPUT).

Absolute voltage levels may vary, relative varies (dc-bias etc.) should stay closely to indicated values.

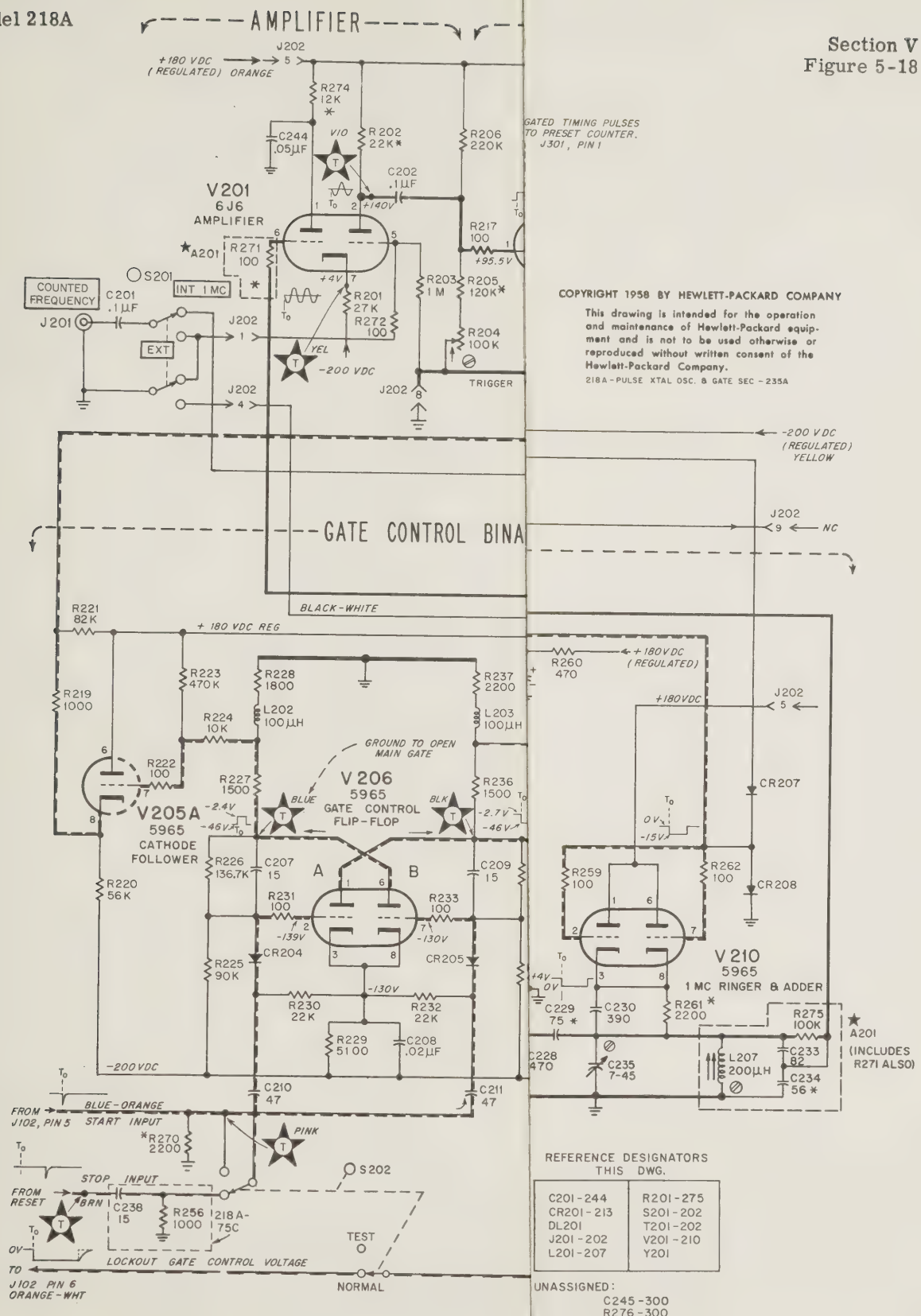
REFERENCE DESIGNATORS THIS DWG.

C101 – 116
CR101 – 105
J103
R101 – 130
S101 – 102
T102
V101 – 103

UNASSIGNED:
C111, 113, 117–200
R131–200

DELETED:
R128

Figure 5-17. Input and Rate Generator Circuit

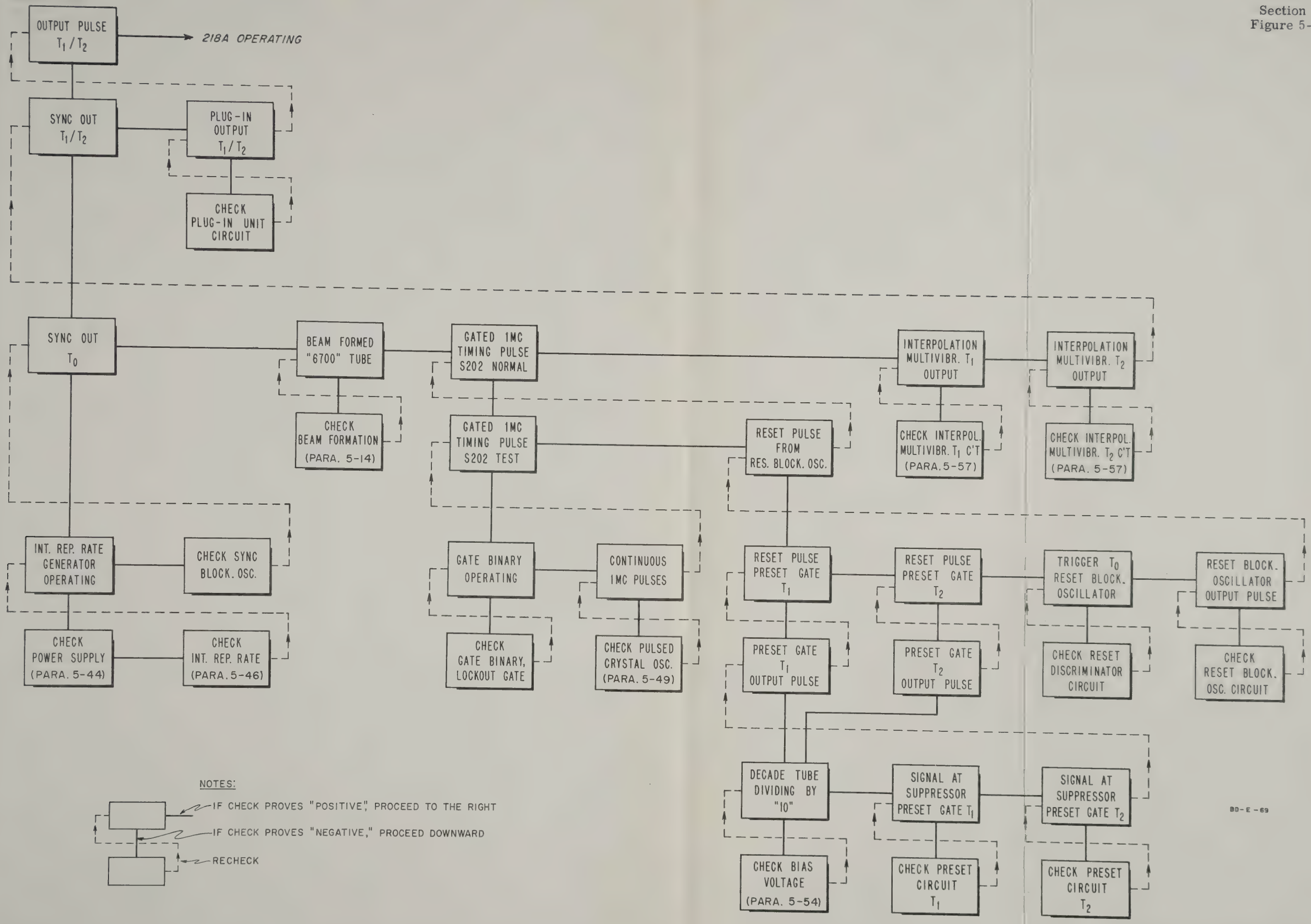


REFERENCE DESIGNATORS THIS DWG.

C201-244	R201-275
CR201-213	S201-202
DL201	T201-202
J201-202	V201-210
L201-207	Y201

UNASSIGNED:
C245-300
R276-300
DELETED: C231

Pulsed Xtal Oscillator and Gate Section



00095-1

Figure 5-2. Troubleshooting

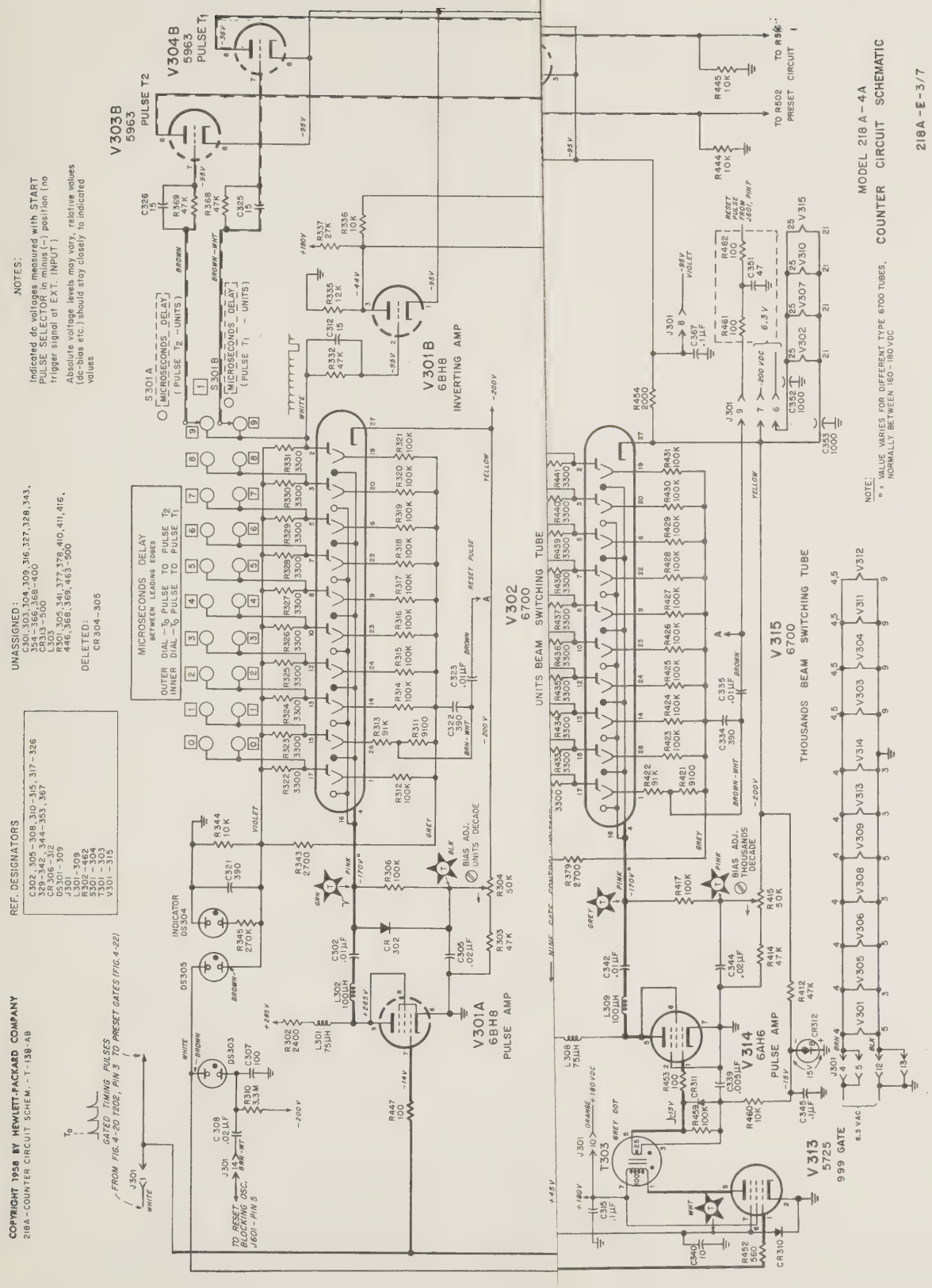


Figure 5-19. Counter Circuit

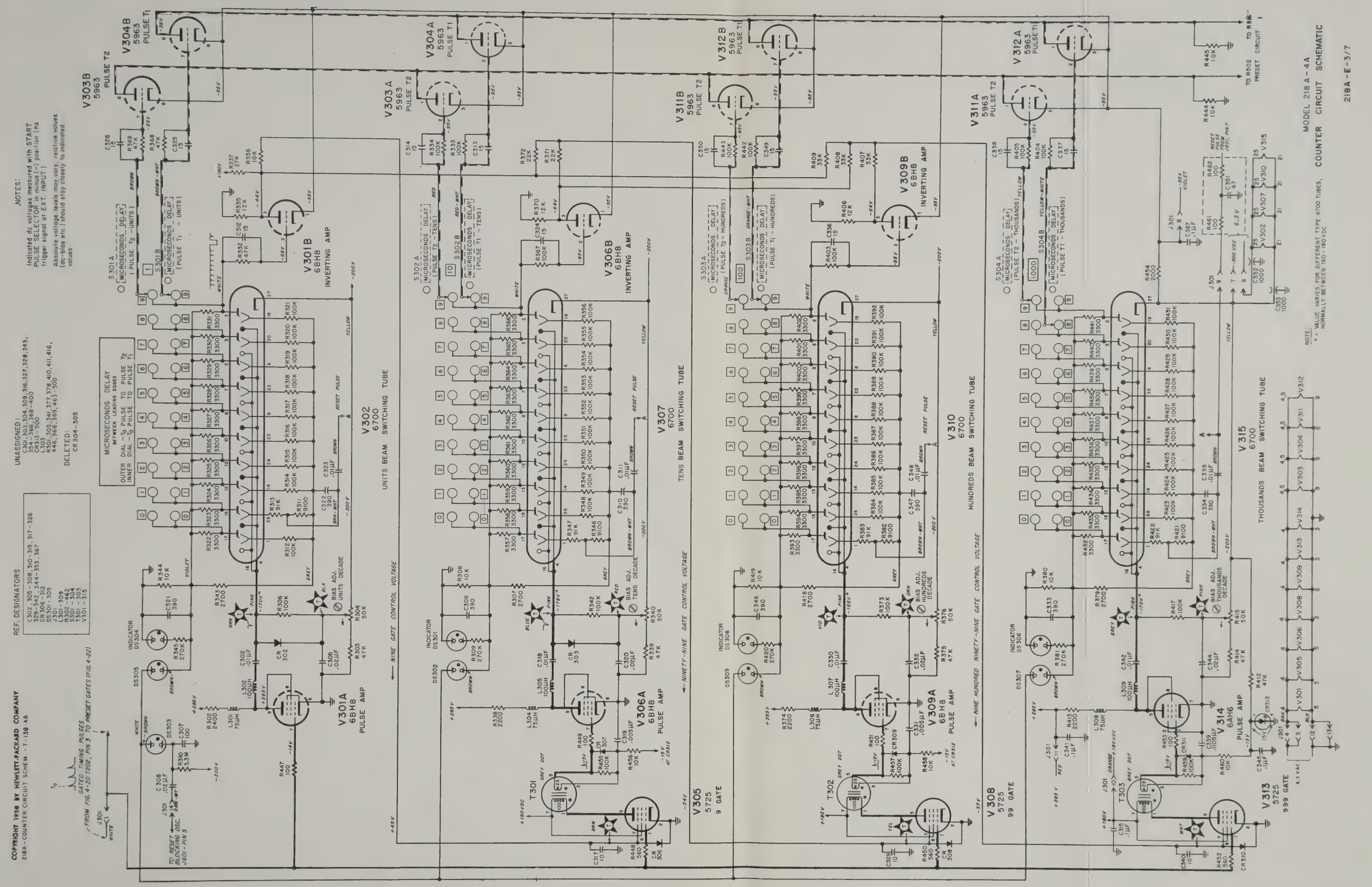


Figure 5-19. Counter Circuit

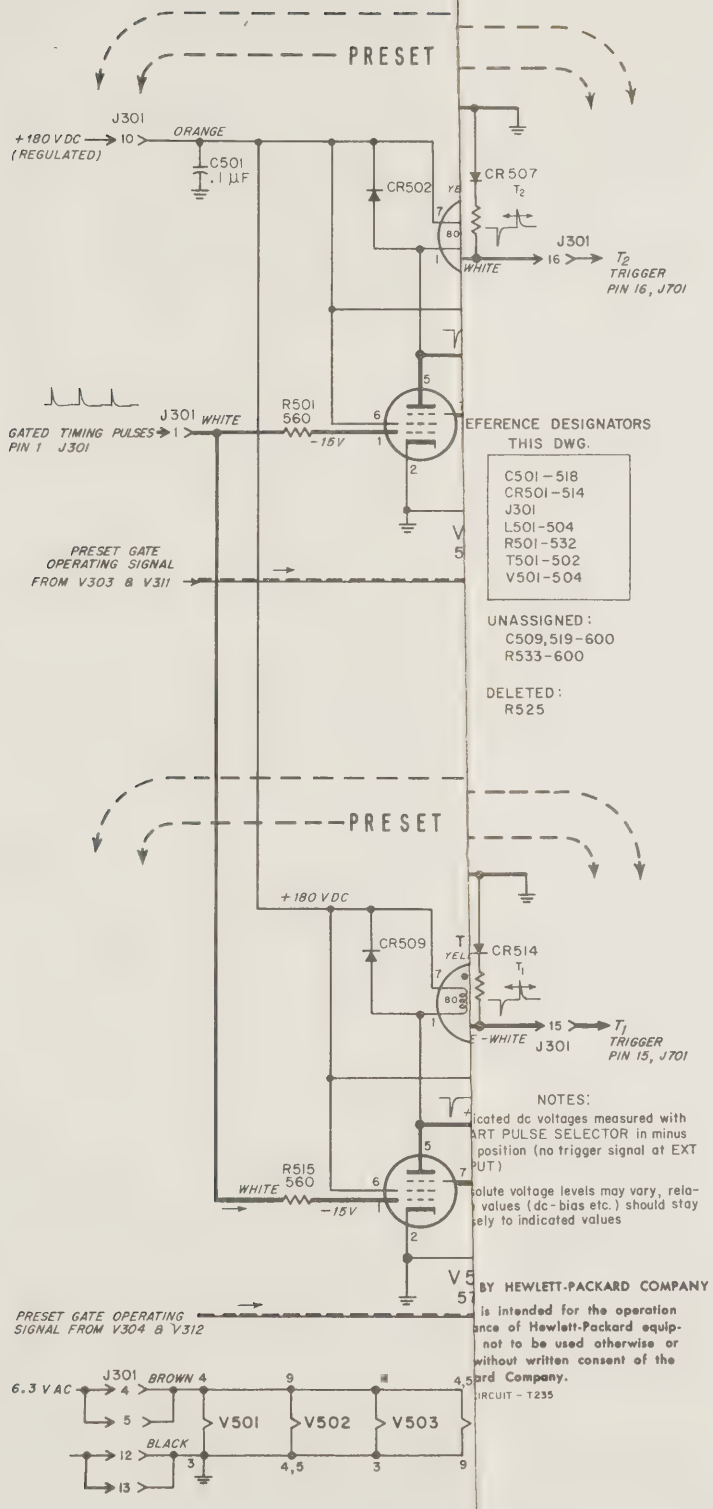


Figure 5-20. Preset Circuit

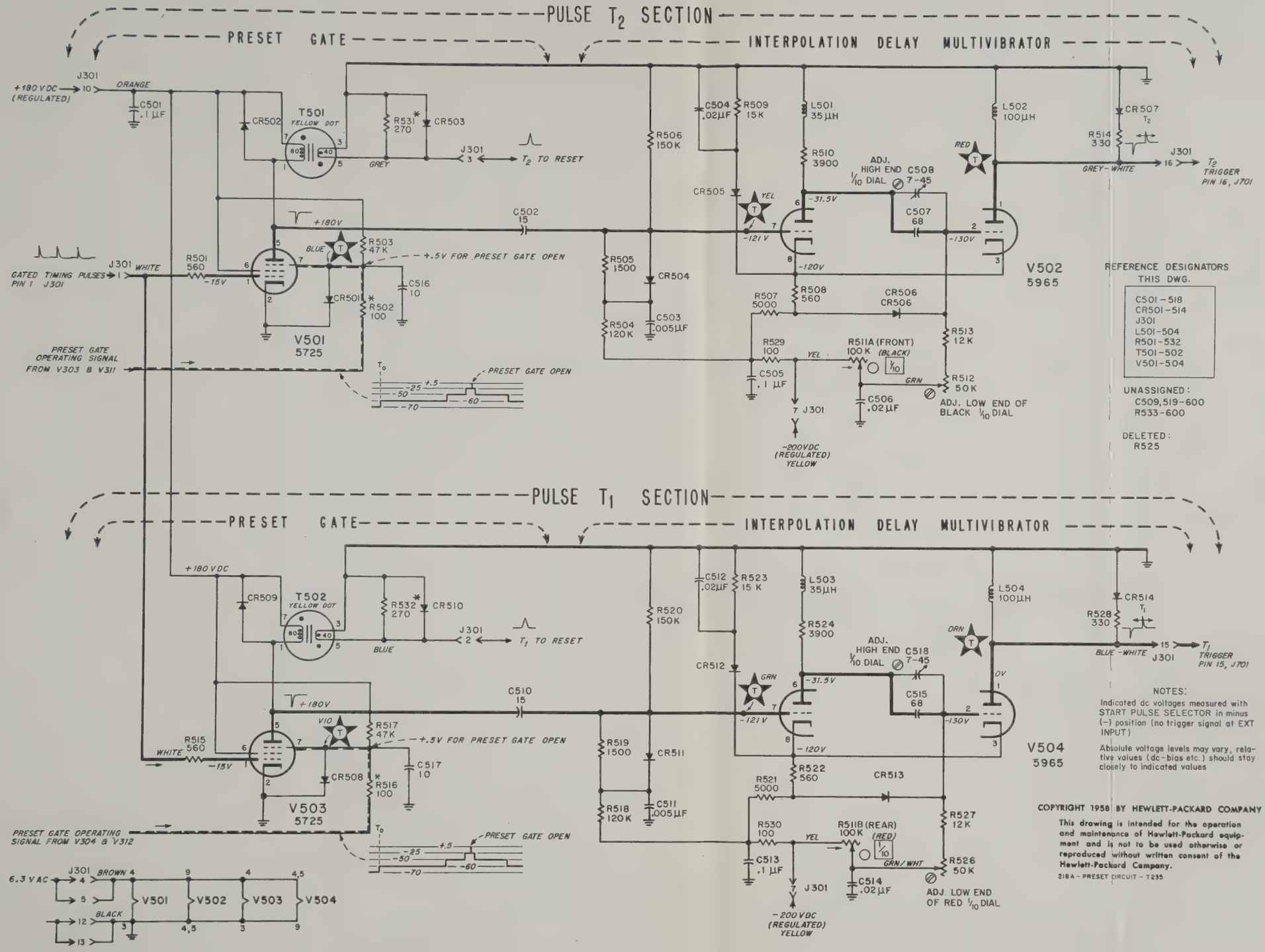


Figure 5-20. Preset Circuit

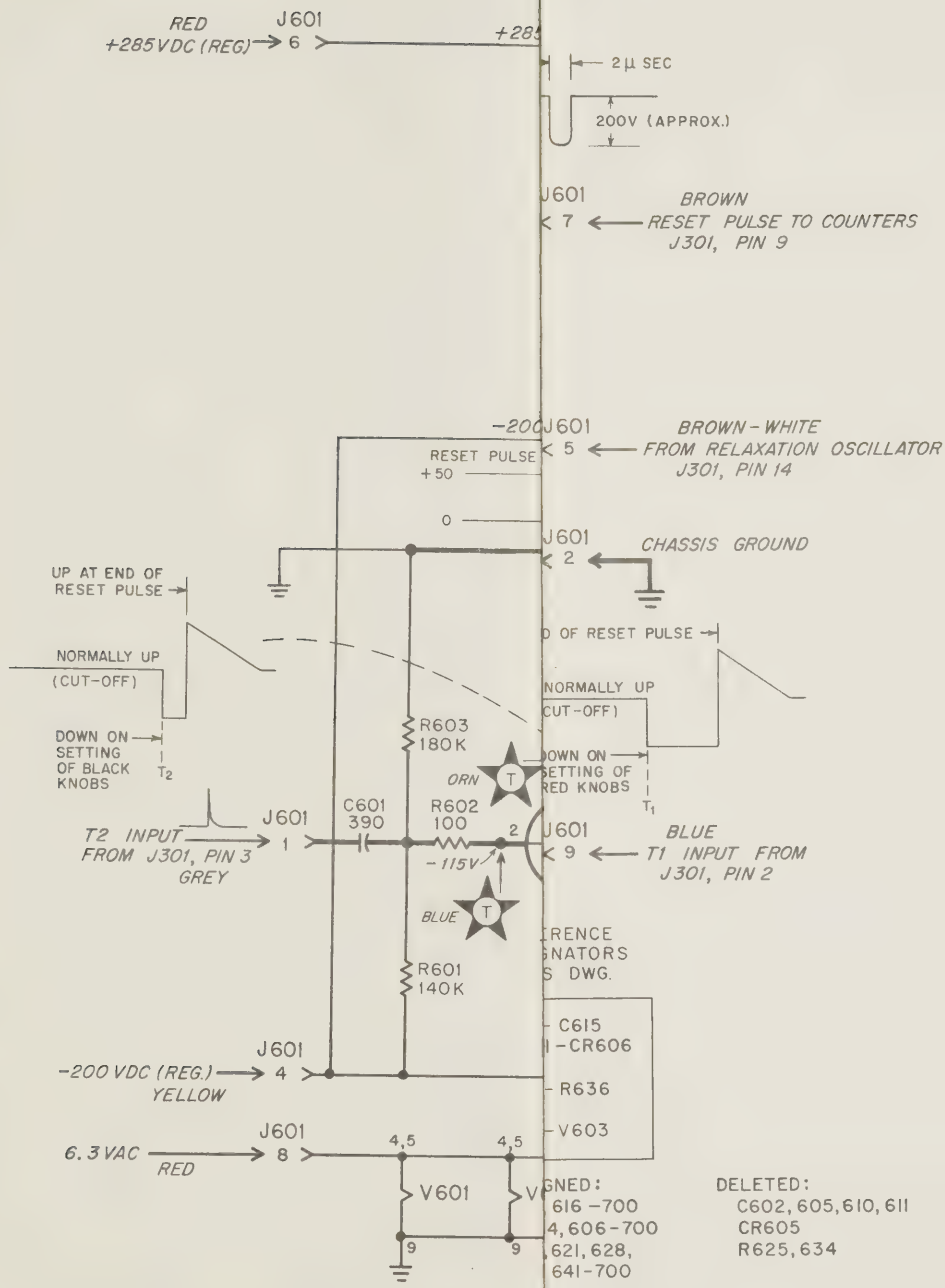
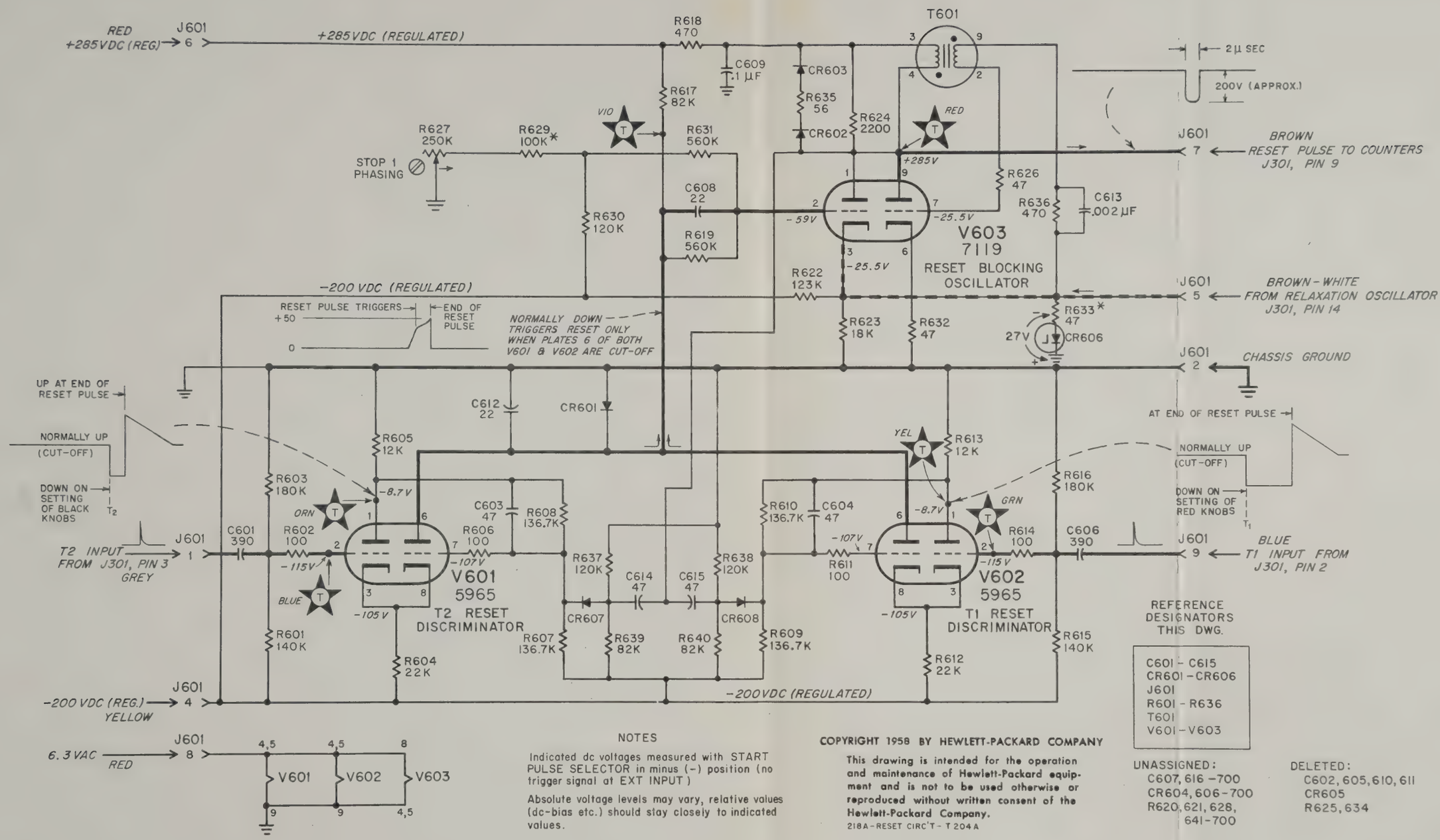


Figure 5-21. Reset Circuit



REFERENCE DESIGNATORS THIS DWG.

C601 - C615
CR601 - CR606
J601
R601 - R636
T601
V601 - V603

UNASSIGNED:
C607, 616 -700
CR604, 606-700
R620, 621, 628, 641-700

DELETED:
C602, 605, 610, 611
CR605
R625, 634

NOTES

Indicated dc voltages measured with START PULSE SELECTOR in minus (-) position (no trigger signal at EXT INPUT)

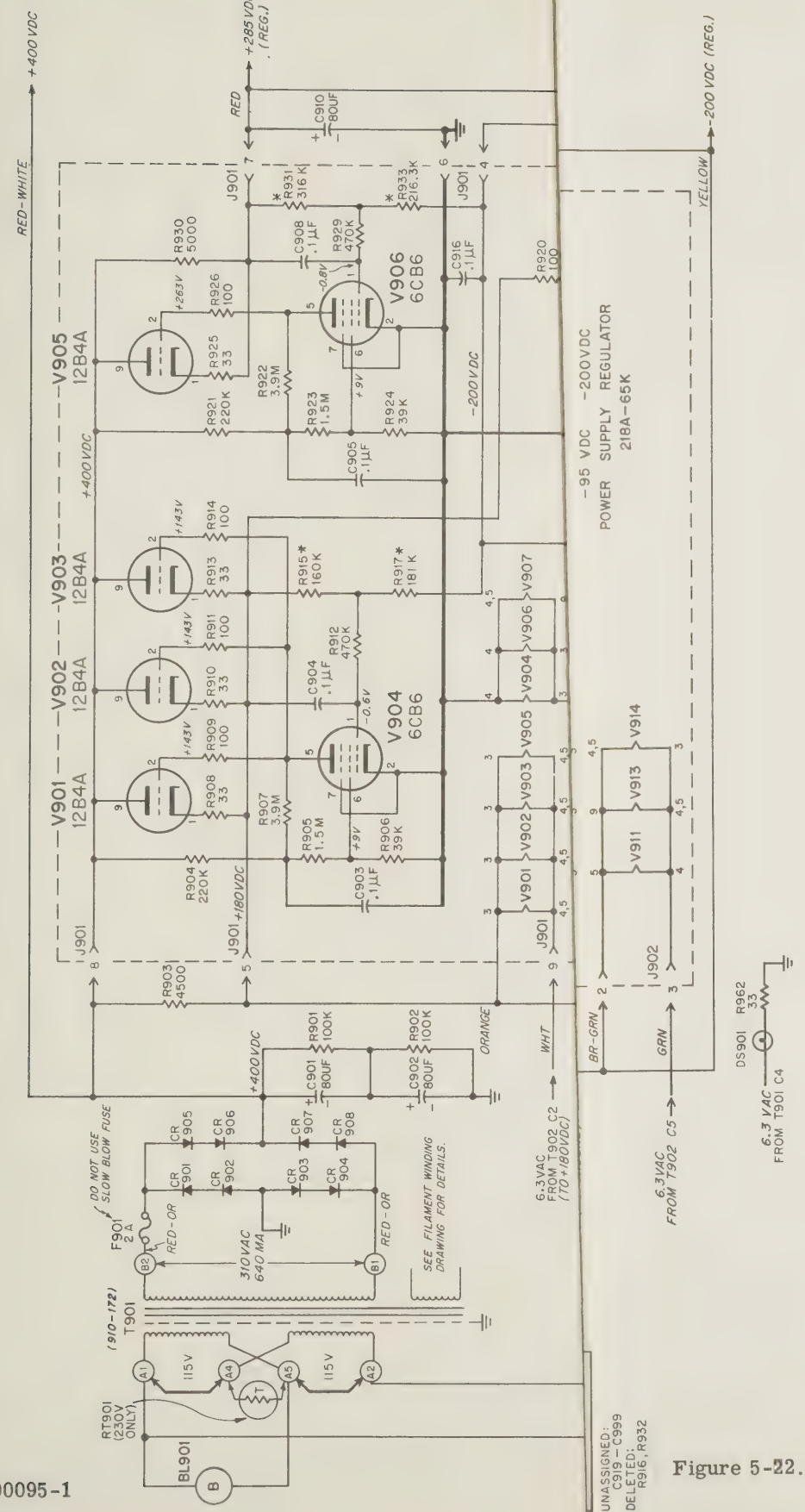
Absolute voltage levels may vary, relative values (dc-bias etc.) should stay closely to indicated values.

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218A-RESET CIRC'T-T 204A

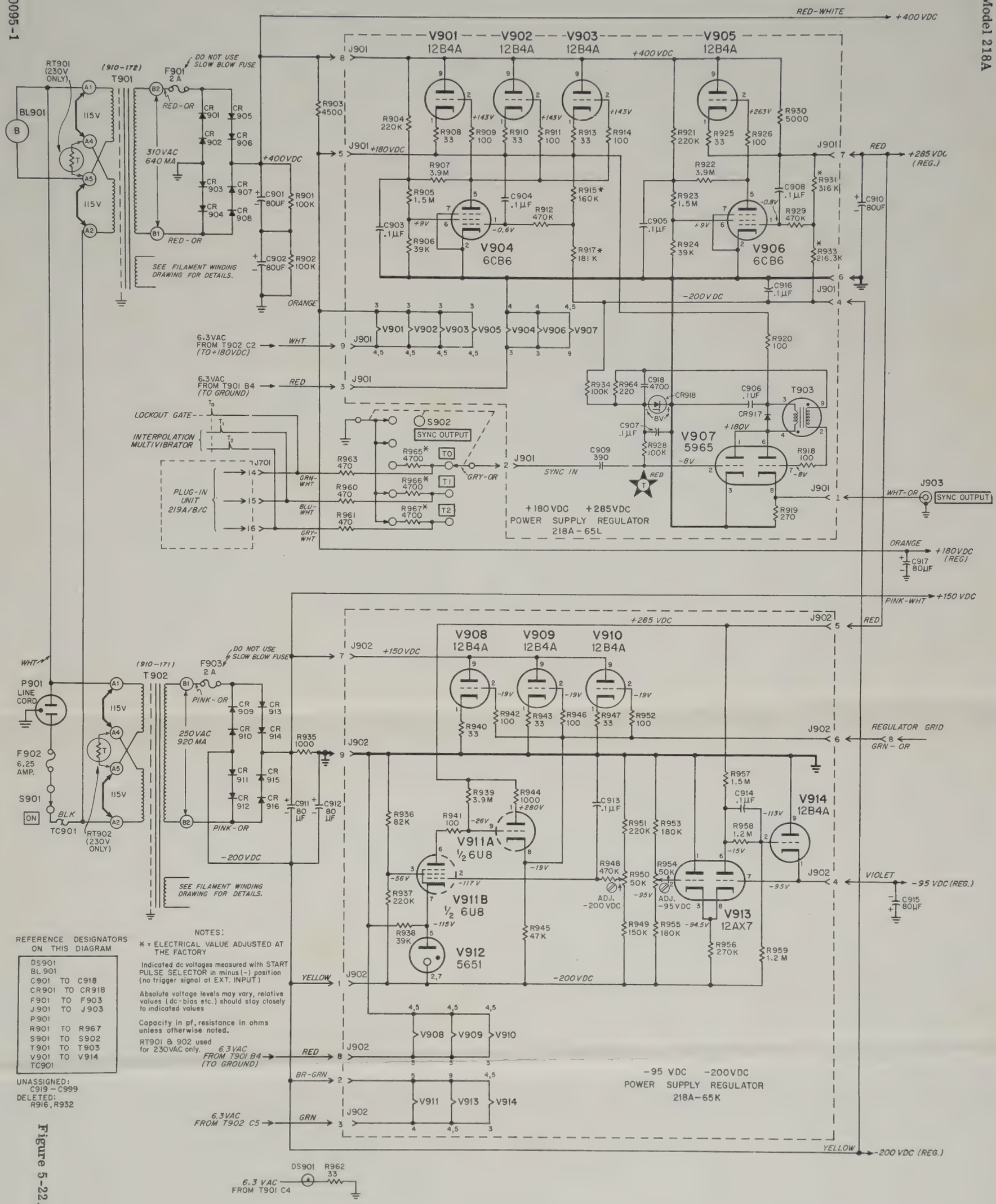
Figure 5-21. Reset Circuit



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218A-PS-T235C

Figure 5-22. Power Supply

00095-1



REFERENCE DESIGNATORS ON THIS DIAGRAM

DS901		
BL 901		
C901	TO	C918
CR901	TO	CR918
F901	TO	F903
J 901	TO	J 903
P 901		
R901	TO	R967
S901	TO	S902
T901	TO	T903
V901	TO	V914
TC901		

UNASSIGNED: C919 – C999
DELETED: R916, R932

NOTES:

* = ELECTRICAL VALUE ADJUSTED AT THE FACTORY

Indicated dc voltages measured with START PULSE SELECTOR in minus (–) position (no trigger signal at EXT. INPUT)

Absolute voltage levels may vary, relative values (dc-bias etc.) should stay closely to indicated values

Capacity in pf, resistance in ohms unless otherwise noted.

RT901 & 902 used for 230VAC only.

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218A-PS-T235C

Figure 5-22. Power Supply



LY

OSCILLATOR

55E
MPS

TOR

S

GATE

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218A - FIL. WINDING -

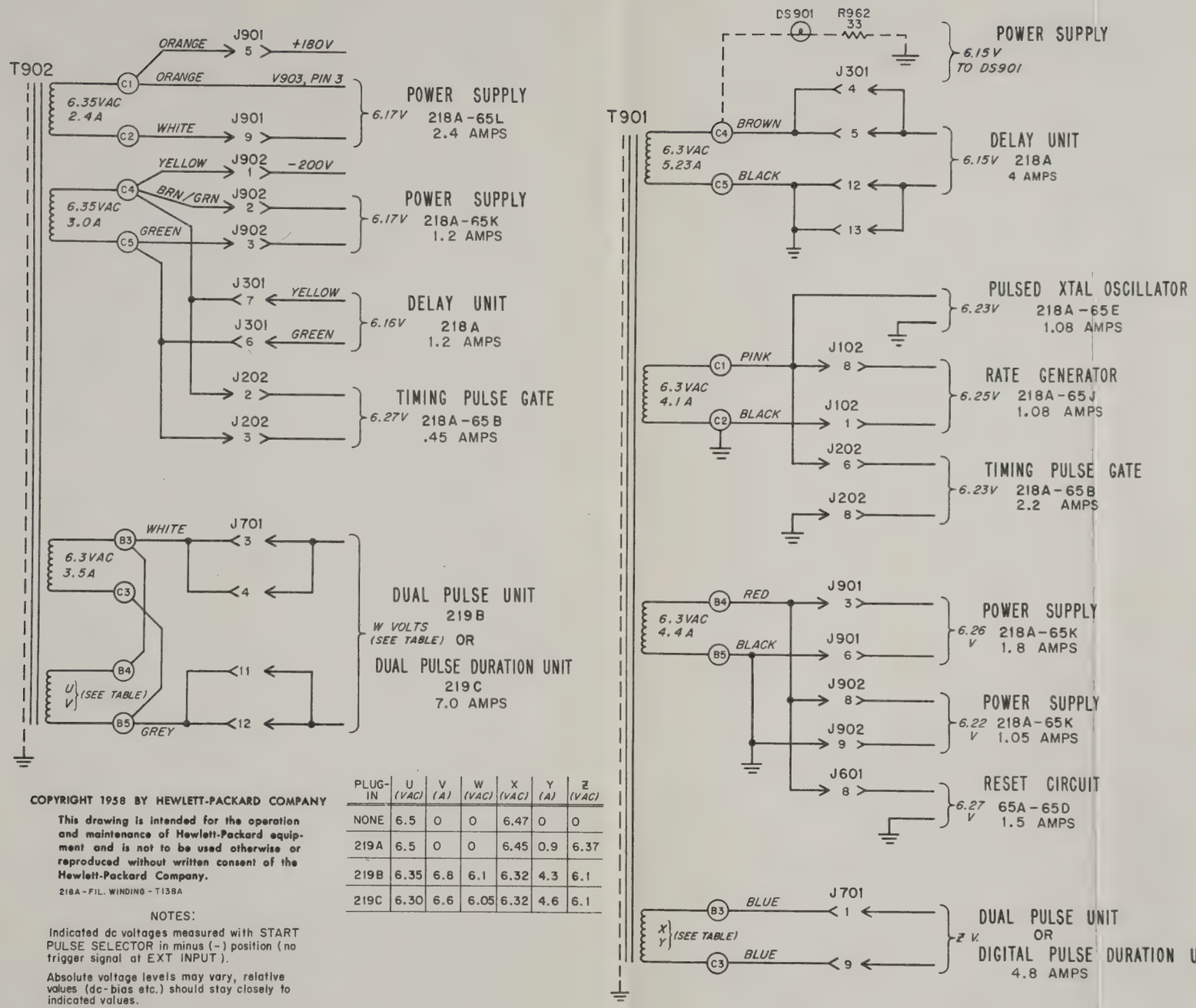
NIT

Indicated dc voltag
PULSE SELECTOR
trigger signal at E

DURATION UNIT

Absolute voltage lev
values (dc-bias etc.
indicated values.

lament Winding Detail, Schematic Diagram



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218A-FIL. WINDING-T138A

NOTES:

Indicated dc voltages measured with START PULSE SELECTOR in minus (-) position (no trigger signal at EXT INPUT).

Absolute voltage levels may vary, relative values (dc-bias etc.) should stay closely to indicated values.

PLUG-IN	U (VAC)	V (A)	W (VAC)	X (VAC)	Y (A)	Z (VAC)
NONE	6.5	0	0	6.47	0	0
219A	6.5	0	0	6.45	0.9	6.37
219B	6.35	6.8	6.1	6.32	4.3	6.1
219C	6.30	6.6	6.05	6.32	4.6	6.1

Figure 5-23. Filament Winding Detail, Schematic Diagram

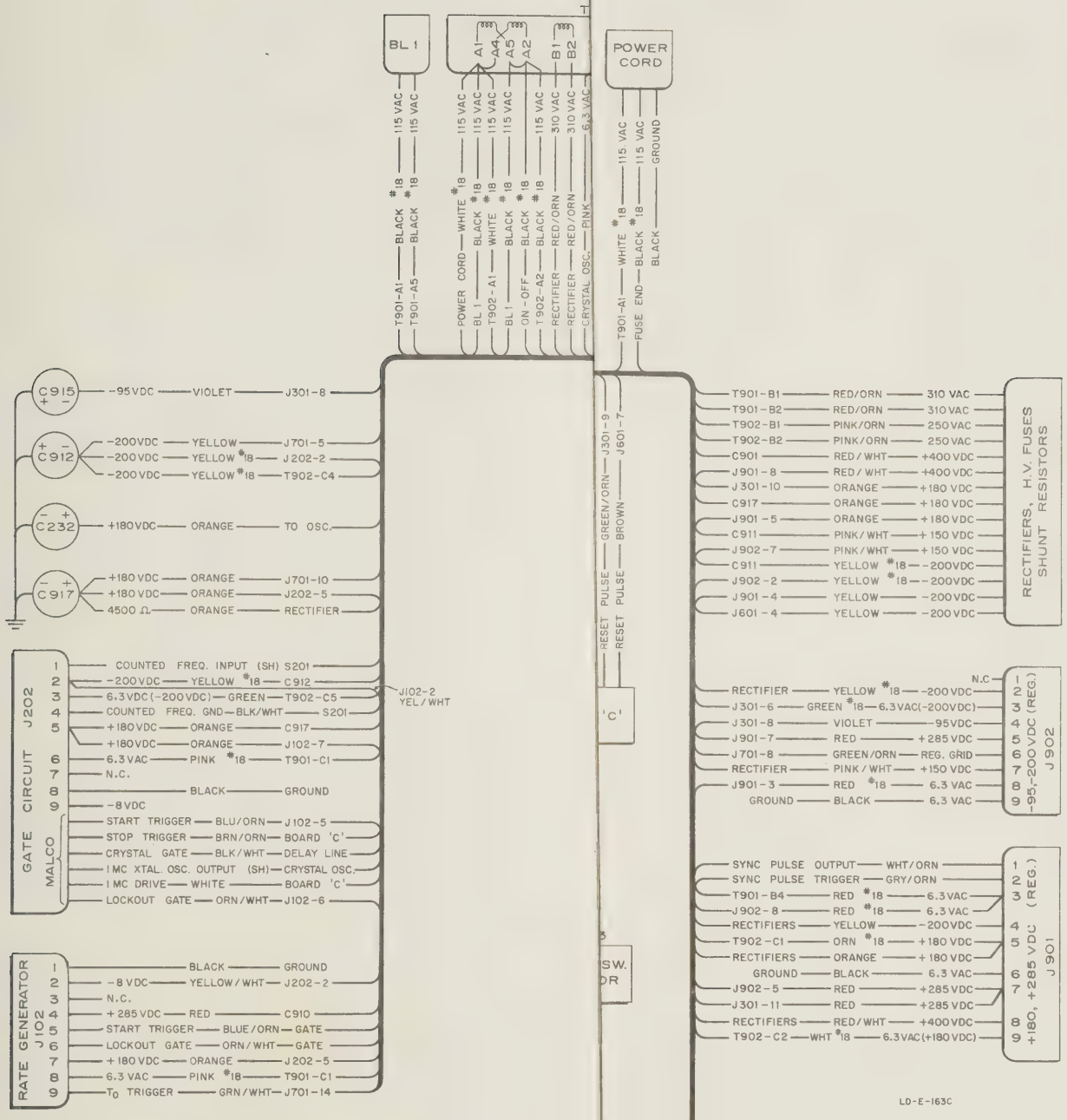


Figure 5-24. Cable Diagram

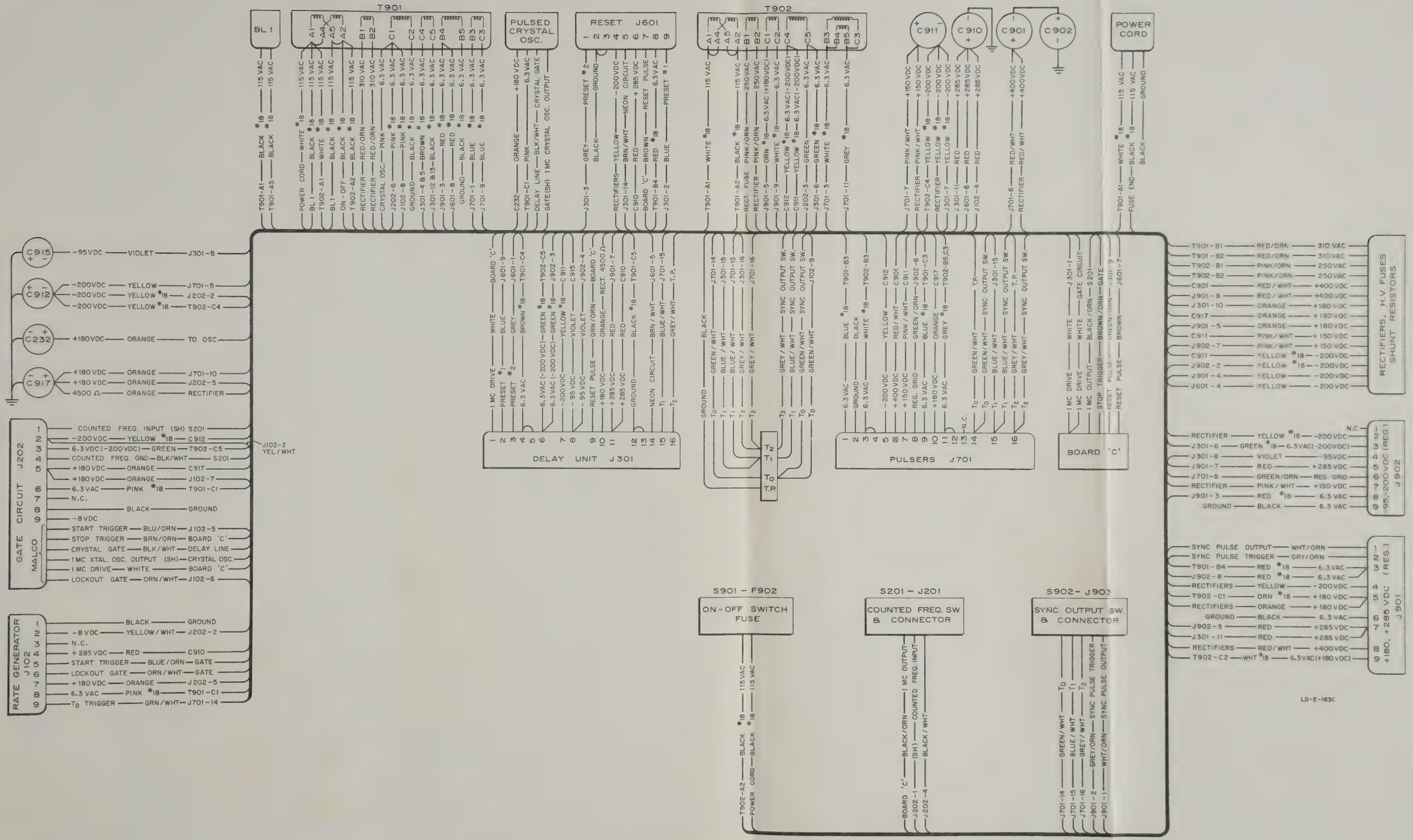


Figure 5-24. Cable Diagram

SECTION VI
REPLACEABLE PARTS

6-1. INTRODUCTION.

6-2. This section contains information for ordering replacement parts. Table 6-1 lists parts in alpha-numerical order of their reference designators and indicates the description and ℎ stock number of each part, together with any applicable notes. Table 6-2 lists parts in alpha-numerical order of their ℎ stock numbers and provides the following information on each part:

a. Description of the part (see list of abbreviations below).

b. Typical manufacturer of the part in a five-digit code; see list of manufacturers in appendix.

c. Manufacturer's stock number.

d. Total quantity used in the instrument (TQ column).

e. Recommended spare part quantity for complete maintenance during one year of isolated service (RS column).

6-3. Miscellaneous parts not indexed in table 6-1 are listed at the end of table 6-2.

6-4. ORDERING INFORMATION.

6-5. To order a replacement part, address order or inquiry either to your authorized Hewlett-Packard sales representative or to

CUSTOMER SERVICE
Hewlett-Packard Company
395 Page Mill Road
Palo Alto, California

or, in Western Europe, to

Hewlett-Packard S.A.
54-54bis Route des Acacias
Geneva, Switzerland

6-6. Specify the following information for each part:

a. Model and complete serial number of instrument.

b. Hewlett-Packard stock number.

c. Circuit reference designator.

d. Description.

6-7. To order a part not listed in tables 6-1 and 6-2, give a complete description of the part and include its function and location.

REFERENCE DESIGNATORS

A = assembly
B = motor
C = capacitor
CR = diode
DL = delay line
DS = device signaling (lamp)
E = misc electronic part
F = fuse
FL = filter
J = jack
K = relay
L = inductor
M = meter
MP = mechanical part
P = plug
Q = transistor
R = resistor
RT = thermistor
S = switch
T = transformer
V = vacuum tube, neon bulb, photocell, etc.
W = cable
X = socket
XF = fuseholder
XDS = lampholder
Z = network

ABBREVIATIONS

A = amperes
BP = bandpass
BWO = backward wave oscillator
CER = ceramic
CMO = cabinet mount only
COEF = coefficient
COM = common
COMP = composition
CONN = connection
CRT = cathode-ray tube
DEPC = deposited carbon
EIA = Tubes or transistors meeting Electronic Industries' Association standards will normally result in instrument operating within specifications; tubes and transistors selected for best performance will be supplied if ordered by ℎ stock numbers.
ELECT = electrolytic
ENCAP = encapsulated
F = farads
FXD = fixed
GE = germanium
GL = glass
GRD = ground(ed)
H = henries
HG = mercury
HR = hour(s)
IMPG = impregnated
INCD = incandescent
INS = insulation (ed)
K = kilo = 1000
LIN = linear taper
LOG = logarithmic taper
M = meg = 10^6
MA = milliamperes
MINAT = miniature
METFLM = metal film
MFR = manufacturer
MTG = mounting
MY = mylar
NC = normally closed
NE = neon
NO = normally open
NPO = negative positive zero (zero temperature coefficient)
NSR = not separately replaceable
OBD = order by description
P = peak
PC = printed circuit board
PF = picofarads = 10^{-12} farads
PP = peak-to-peak
PIV = peak inverse voltage
POR = porcelain
POS = position(s)
POLY = polystyrene
POT = potentiometer
RECT = rectifier
ROT = rotary
RMS = root-mean-square
RMO = rack mount only
S-B = slow-blow
SE = selenium
SECT = section(s)
SI = silicon
SIL = silver
SL = slide
TA = tantalum
TD = time delay
TI = titanium dioxide
TOG = toggle
TOL = tolerance
TRIM = trimmer
TWT = traveling wave tube
U = micro = 10^{-6}
VAC = vacuum
VAR = variable
W/ = with
W = watts
WW = wirewound
W/O = without
* = optimum value selected at factory, average value shown (part may be omitted)
= number

01194-5

Table 6-1. Reference Designation Index

Circuit Reference	℗ Stock No.	Description	Note
A201	218A-60F	ASSEMBLY:RINGER COIL	
B901	3140-0006	MOTOR:AC 4 POLE 115 VAC 60 CYCLES 1700RPM	
C101	0170-0022	C:FXD MY 0.1UF 20% 600VDCW	
C102	0180-0051	C:FXD ELECT 8UF 350VDCW	
C103	0140-0042	C:FXD MICA 27 PF 5% 500 VDCW	
C104	0140-0039	C:FXD MICA 47 PF 5% 500 VDCW	
C105	0170-0022	C:FXD MY 0.1UF 20% 600VDCW	
C106	0160-0129	C:FXD MY 2200PF 2% 600VDCW	
C107	0160-0130	C:FXD MY 2200PF 2% 600VDCW	
C108	0160-0131	C:FXD MY 0.22UF 2% 600VDCW	
C109	0140-0037	C:FXD MICA 390 PF 5% 500 VDCW	
C110	0140-0042	C:FXD MICA 27 PF 5% 500 VDCW	
C111		NOT ASSIGNED	
C112	0150-0052	C:FXD 0.05 UF 20% 400 VDCW	
C113		NOT ASSIGNED	
C114	0150-0052	C:FXD 0.05 UF 20% 400 VDCW	
C115	0140-0039	C:FXD MICA 47 PF 5% 500 VDCW ADJUSTABLE, AVERAGE VALUE SHOWN	
C116	0140-0054	C:FXD MICA 100 PF 10% 500 VDCW	
C117 THRU			
C200		NOT ASSIGNED	
C201	0160-0001	C:FXD MY 0.1UF 10% 600VDCW	
C202	0170-0022	C:FXD MY 0.1UF 20% 600VDCW	
C203	0140-0026	C:FXD MICA 22 PF 10% 500 VDCW	
C204	0170-0022	C:FXD MY 0.1UF 20% 600VDCW	
C205	0140-0083	C:FXD MICA 220 PF 5% 500 VDCW	
C206	0170-0022	C:FXD MY 0.1UF 20% 600VDCW	
C207	0140-0101	C:FXD MICA 15PF 5% 500 VDCW	
C208	0140-0024	C:FXD MICA 2200 PF 10% 500 VDCW	
C209	0140-0193	C:FXD MICA 15PF 5% 500 VDCW	
C210	0140-0039	C:FXD MICA 47 PF 5% 500 VDCW	
C211	0140-0039	C:FXD MICA 47 PF 5% 500 VDCW	
C212	0180-0051	C:FXD ELECT 8UF 350VDCW	
C213	0130-0006	C:VAR CER 5-20PF N300	
C214	0140-0036	C:FXD MICA 110 PF 5% 500 VDCW	
C215	0140-0036	C:FXD MICA 110 PF 5% 500 VDCW	
C216	0130-0003	C:VAR C 1.5-7PF 500VDCW	
C217	0140-0037	C:FXD MICA 390 PF 5% 500 VDCW	
C218	0140-0024	C:FXD MICA 2200 PF 10% 500 VDCW	
C219	0140-0139	C:FXD MICA 470 PF 10% 300 VDCW	
C220	0170-0022	C:FXD MY 0.1UF 20% 600VDCW	
C221	0140-0037	C:FXD MICA 390 PF 5% 500 VDCW	
C222	0150-0047	C:FXD TI 6.8 PF 10% 500 VDCW ADJUSTABLE, AVERAGE VALUE SHOWN	
C223	0140-0055	C:FXD MICA 150 PF 10% 500 VDCW	
C224	0140-0092	C:FXD MICA 240 PF 5% 500 VDCW	
C225	0140-0024	C:FXD MICA 2200 PF 10% 500 VDCW	
C226	0170-0022	C:FXD MY 0.1UF 20% 600VDCW	
C227	0140-0039	C:FXD MICA 47 PF 5% 500 VDCW	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference		Stock No.	Description	Note
C228		0140-0027	C:FXD MICA 470 PF 10% 500 VDCW	
C229		0140-0040	C:FXD MICA 75 PF 5% 500 VDCW	
C230		0140-0037	C:FXD MICA 390 PF 5% 500 VDCW	
C231			NOT ASSIGNED	
C232		0180-0020	C:FXD ELECT 80UF -20/+100% 450VDCW	
C233		0140-0193	C:FXD MICA 82 PF 5% 300 VDCW	
C234		0140-0081	C:FXD MICA 56PF +/-1PF ADJUSTABLE: AVERAGE VALUE SHOWN	
C235		0130-0015	C:VAR CER 9-50 PF N750	
C236		0140-0024	C:FXD MICA 2200 PF 10% 500 VDCW	
C237		0130-0001	C:VAR CER 7-45 PF N500	
C238		0140-0004	C:FXD MICA 15 PF 10% 500VDCW	
C239		0140-0054	C:FXD MICA 100 PF 10% 500 VDCW	
C240		0170-0022	C:FXD MY 0.1UF 20% 600VDCW	
C241		0140-0004	C:FXD MICA 15 PF 10% 500VDCW	
C242		0170-0022	C:FXD MY 0.1UF 20% 600VDCW	
C243		0170-0022	C:FXD MY 0.1UF 20% 600VDCW	
C244		0150-0052	C:FXD 0.05 UF 20% 400 VDCW	
C245	THRU			
C301			NOT ASSIGNED	
C302		0150-0012	C:FXD CER 0.01UF 20% 1000VDCW	
C303	THRU			
C304			NOT ASSIGNED	
C305		0140-0024	C:FXD MICA 2200 PF 10% 500 VDCW	
C306		0140-0030	C:FXD MICA 390 PF 10% 500 VDCW	
C307		0150-0073	C:FXD CER 100 PF 10% 500 VDCW	
C308		0140-0024	C:FXD MICA 2200 PF 10% 500 VDCW	
C309			NOT ASSIGNED	
C310		0140-0030	C:FXD MICA 390 PF 10% 500 VDCW	
C311		0150-0012	C:FXD CER 0.01UF 20% 1000VDCW	
C312		0140-0004	C:FXD MICA 15 PF 10% 500VDCW	
C313		0140-0004	C:FXD MICA 15 PF 10% 500VDCW	
C314		0140-0004	C:FXD MICA 15 PF 10% 500VDCW	
C315		0170-0022	C:FXD MY 0.1UF 20% 600VDCW	
C316			NOT ASSIGNED	
C317		0150-0009	C:FXD CER 10PF +/-0.5PF NPO 500VDCW	
C318		0150-0012	C:FXD CER 0.01UF 20% 1000VDCW	
C319		0150-0014	C:FXD CER 5000PF MIN 500VDCW	
C320		0140-0024	C:FXD MICA 2200 PF 10% 500 VDCW	
C321		0140-0030	C:FXD MICA 390 PF 10% 500 VDCW	
C322		0140-0030	C:FXD MICA 390 PF 10% 500 VDCW	
C323		0150-0012	C:FXD CER 0.01UF 20% 1000VDCW	
C324		0140-0004	C:FXD MICA 15 PF 10% 500VDCW	
C325		0140-0004	C:FXD MICA 15 PF 10% 500VDCW	
C326		0140-0004	C:FXD MICA 15 PF 10% 500VDCW	
C327	THRU			
C328			NOT ASSIGNED	
C329		0150-0009	C:FXD CER 10PF +/-0.5PF NPO 500VDCW	
C330		0150-0012	C:FXD CER 0.01UF 20% 1000VDCW	
C331		0150-0014	C:FXD CER 5000PF MIN 500VDCW	
C332		0140-0024	C:FXD MICA 2200 PF 10% 500 VDCW	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference		Stock No.	Description	Note
C333		0140-0030	C:FXD MICA 390 PF 10% 500 VDCW	
C334		0140-0030	C:FXD MICA 390 PF 10% 500 VDCW	
C335		0150-0012	C:FXD CER 0.01UF 20% 1000VDCW	
C336		0140-0004	C:FXD MICA 15 PF 10% 500VDCW	
C337		0140-0004	C:FXD MICA 15 PF 10% 500VDCW	
C338		0140-0004	C:FXD MICA 15 PF 10% 500VDCW	
C339		0150-0014	C:FXD CER 5000PF MIN 500VDCW	
C340		0150-0009	C:FXD CER 10PF +/-0.5PF NPO 500VDCW	
C341		0170-0022	C:FXD MY 0.1UF 20% 600VDCW	
C342		0150-0012	C:FXD CER 0.01UF 20% 1000VDCW	
C343			NOT ASSIGNED	
C344		0140-0024	C:FXD MICA 2200 PF 10% 500 VDCW	
C345		0170-0022	C:FXD MY 0.1UF 20% 600VDCW	
C346		0140-0030	C:FXD MICA 390 PF 10% 500 VDCW	
C347		0140-0030	C:FXD MICA 390 PF 10% 500 VDCW	
C348		0150-0012	C:FXD CER 0.01UF 20% 1000VDCW	
C349		0140-0004	C:FXD MICA 15 PF 10% 500VDCW	
C350		0140-0004	C:FXD MICA 15 PF 10% 500VDCW	
C351		0140-0032	C:FXD MICA 47 PF 10% 500 VDCW	
C352		0150-0019	C:FXD CER 1000PF 20%	
C353		0150-0019	C:FXD CER 1000PF 20%	
C354	THRU			
C366			NOT ASSIGNED	
C367		0170-0022	C:FXD MY 0.1UF 20% 600VDCW	
C368	THRU			
C500			NOT ASSIGNED	
C501		0170-0022	C:FXD MY 0.1UF 20% 600VDCW	
C502		0140-0004	C:FXD MICA 15 PF 10% 500VDCW	
C503		0150-0014	C:FXD CER 5000PF MIN 500VDCW	
C504		0140-0024	C:FXD MICA 2200 PF 10% 500 VDCW	
C505		0170-0022	C:FXD MY 0.1UF 20% 600VDCW	
C506		0140-0024	C:FXD MICA 2200 PF 10% 500 VDCW	
C507		0140-0025	C:FXD MICA 68 PF 10% 500 VDCW	
C508		0131-0004	C:VAR MICA 16-150 PF 175VDCW	
C509			NOT ASSIGNED	
C510		0140-0004	C:FXD MICA 15 PF 10% 500VDCW	
C511		0150-0014	C:FXD CER 5000PF MIN 500VDCW	
C512		0140-0024	C:FXD MICA 2200 PF 10% 500 VDCW	
C513		0170-0022	C:FXD MY 0.1UF 20% 600VDCW	
C514		0140-0024	C:FXD MICA 2200 PF 10% 500 VDCW	
C515		0140-0025	C:FXD MICA 68 PF 10% 500 VDCW	
C516		0150-0009	C:FXD CER 10PF +/-0.5PF NPO 500VDCW	
C517		0150-0009	C:FXD CER 10PF +/-0.5PF NPO 500VDCW	
C518		0131-0004	C:VAR MICA 16-150 PF 175VDCW	
C519	THRU			
C600			NOT ASSIGNED	
C601		0140-0037	C:FXD MICA 390 PF 5% 500 VDCW	
C602			NOT ASSIGNED	
C603		0140-0039	C:FXD MICA 47 PF 5% 500 VDCW	
C604		0140-0039	C:FXD MICA 47 PF 5% 500 VDCW	
C605			NOT ASSIGNED	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	℗ Stock No.	Description	Note
C606	0140-0037	C:FXD MICA 390 PF 5% 500 VDCW	
C607		NOT ASSIGNED	
C608	0140-0034	C:FXD MICA 22 PF 5% 500 VDCW	
C609	0170-0022	C:FXD MY 0.1UF 20% 600VDCW	
C610 THRU			
C611		NOT ASSIGNED	
C612	0140-0034	C:FXD MICA 22 PF 5% 500 VDCW	
C613	0150-0023	C:FXD CER 2000PF 20% 1000VDCW	
C614	0140-0039	C:FXD MICA 47 PF 5% 500 VDCW	
C615	0140-0039	C:FXD MICA 47 PF 5% 500 VDCW	
C616 THRU			
C900		NOT ASSIGNED	
C901	0180-0020	C:FXD ELECT 80UF -20/+100% 450VDCW	
C902	0180-0020	C:FXD ELECT 80UF -20/+100% 450VDCW	
C903	0170-0022	C:FXD MY 0.1UF 20% 600VDCW	
C904	0170-0022	C:FXD MY 0.1UF 20% 600VDCW	
C905	0170-0022	C:FXD MY 0.1UF 20% 600VDCW	
C906	0170-0022	C:FXD MY 0.1UF 20% 600VDCW	
C907		NOT ASSIGNED	
C908	0170-0022	C:FXD MY 0.1UF 20% 600VDCW	
C909	0140-0037	C:FXD MICA 390 PF 5% 500 VDCW	
C910	0180-0020	C:FXD ELECT 80UF -20/+100% 450VDCW	
C911	0180-0020	C:FXD ELECT 80UF -20/+100% 450VDCW	
C912	0180-0020	C:FXD ELECT 80UF -20/+100% 450VDCW	
C913	0170-0022	C:FXD MY 0.1UF 20% 600VDCW	
C914	0170-0022	C:FXD MY 0.1UF 20% 600VDCW	
C915	0180-0020	C:FXD ELECT 80UF -20/+100% 450VDCW	
C916	0170-0022	C:FXD MY 0.1UF 20% 600VDCW	
C917	0180-0020	C:FXD ELECT 80UF -20/+100% 450VDCW	
C918	0150-0075	C:FXD CER 4700 PF +100%-20% 500 V	
CR101	1910-0011	DIODE GERMANIUM 5MA AT 1V 60 PIV	
CR102	1910-0011	DIODE GERMANIUM 5MA AT 1V 60 PIV	
CR103	1910-0011	DIODE GERMANIUM 5MA AT 1V 60 PIV	
CR104	G31G-8A	SEMICON DEVICE:DIODE	
CR105	1910-0011	DIODE GERMANIUM 5MA AT 1V 60 PIV	
CR106 THRU			
CR200		NOT ASSIGNED	
CR201	1910-0011	DIODE GERMANIUM 5MA AT 1V 60 PIV	
CR202	1910-0011	DIODE GERMANIUM 5MA AT 1V 60 PIV	
CR203	1910-0011	DIODE GERMANIUM 5MA AT 1V 60 PIV	
CR204	1910-0011	DIODE GERMANIUM 5MA AT 1V 60 PIV	
CR205	1910-0011	DIODE GERMANIUM 5MA AT 1V 60 PIV	
CR206	1910-0011	DIODE GERMANIUM 5MA AT 1V 60 PIV	
CR207	1910-0011	DIODE GERMANIUM 5MA AT 1V 60 PIV	
CR208	1910-0011	DIODE GERMANIUM 5MA AT 1V 60 PIV	
CR209	1910-0011	DIODE GERMANIUM 5MA AT 1V 60 PIV	
CR210	G31G-8A	SEMICON DEVICE:DIODE	
CR211	G-31G-15A	SEMICON DEVICE:DIODE SILICON	
CR212	1910-0011	DIODE GERMANIUM 5MA AT 1V 60 PIV	
CR213	1910-0011	DIODE GERMANIUM 5MA AT 1V 60 PIV	
CR214 THRU			
CR301		NOT ASSIGNED	

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Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	Stock No.	Description	Note
CR302	G-29F-85	SEMICON DEVICE:DIODE IN55	
CR303	G-29F-85	SEMICON DEVICE:DIODE IN55	
CR304 THRU			
CR305		NOT ASSIGNED	
CR306	G-29F-85	SEMICON DEVICE:DIODE IN55	
CR307	1910-0011	DIODE GERMANIUM 5MA AT 1V 60 PIV	
CR308	G-29F-85	SEMICON DEVICE:DIODE IN55	
CR309	1910-0011	DIODE GERMANIUM 5MA AT 1V 60 PIV	
CR310	G-29F-85	SEMICON DEVICE:DIODE IN55	
CR311	1910-0011	DIODE GERMANIUM 5MA AT 1V 60 PIV	
CR312	G-31G-15A	SEMICON DEVICE:DIODE SILICON	
CR313 THRU			
CR500		NOT ASSIGNED	
CR501	G-29F-85	SEMICON DEVICE:DIODE 1N55	
CR502	1910-0011	DIODE GERMANIUM 5MA AT 1V 60 PIV	
CR503	1910-0011	DIODE GERMANIUM 5MA AT 1V 60 PIV	
CR504	1910-0011	DIODE GERMANIUM 5MA AT 1V 60 PIV	
CR505	1910-0011	DIODE GERMANIUM 5MA AT 1V 60 PIV	
CR506	1910-0011	DIODE GERMANIUM 5MA AT 1V 60 PIV	
CR507	1910-0011	DIODE GERMANIUM 5MA AT 1V 60 PIV	
CR508	G-29F-85	SEMICON DEVICE:DIODE 1N55	
CR509	1910-0011	DIODE GERMANIUM 5MA AT 1V 60 PIV	
CR510	1910-0011	DIODE GERMANIUM 5MA AT 1V 60 PIV	
CR511	1910-0011	DIODE GERMANIUM 5MA AT 1V 60 PIV	
CR512	1910-0011	DIODE GERMANIUM 5MA AT 1V 60 PIV	
CR513	1910-0011	DIODE GERMANIUM 5MA AT 1V 60 PIV	
CR514	1910-0011	DIODE GERMANIUM 5MA AT 1V 60 PIV	
CR515 THRU			
CR600		NOT ASSIGNED	
CR601	1901-0033	SEMICON DEVICE DIODE 1N485B	
CR602	1901-0033	SEMICON DEVICE DIODE 1N485B	
CR603	1901-0033	SEMICON DEVICE DIODE 1N485B	
CR604 THRU			
CR605		NOT ASSIGNED	
CR606	G-31G-27H	SEMICON DEVICE:DIODE 27VOLT	
CR607	1901-0033	SEMICON DEVICE DIODE 1N485B	
CR608	1901-0033	SEMICON DEVICE DIODE 1N485B	
CR609 THRU			
CR900		NOT ASSIGNED	
CR901	1901-0028	DIODE SILICON PIV 400V I AVGE 0.75A	
CR902	1901-0028	DIODE SILICON PIV 400V I AVGE 0.75A	
CR903	1901-0028	DIODE SILICON PIV 400V I AVGE 0.75A	
CR904	1901-0028	DIODE SILICON PIV 400V I AVGE 0.75A	
CR905	1901-0028	DIODE SILICON PIV 400V I AVGE 0.75A	
CR906	1901-0028	DIODE SILICON PIV 400V I AVGE 0.75A	
CR907	1901-0028	DIODE SILICON PIV 400V I AVGE 0.75A	
CR908	1901-0028	DIODE SILICON PIV 400V I AVGE 0.75A	
CR909	1901-0028	DIODE SILICON PIV 400V I AVGE 0.75A	
CR910	1901-0028	DIODE SILICON PIV 400V I AVGE 0.75A	
CR911	1901-0028	DIODE SILICON PIV 400V I AVGE 0.75A	
CR912	1901-0028	DIODE SILICON PIV 400V I AVGE 0.75A	

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Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference		℗ Stock No.	Description	Note
CR913		1901-0028	DIODE SILICON PIV 400V I AVGE 0.75A	
CR914		1901-0028	DIODE SILICON PIV 400V I AVGE 0.75A	
CR915		1901-0028	DIODE SILICON PIV 400V I AVGE 0.75A	
CR916		1901-0028	DIODE SILICON PIV 400V I AVGE 0.75A	
CR917		G-29F-85	SEMICON DEVICE:DIODE 1N55	
CR918		G31G-8A	SEMICON DEVICE:DIODE	
DL201		9190-0002	DELAY LINE 0.5 U-SEC. 1700 IMP.	
DS301		2140-0006	LAMP GLOW NE-2 NEON	
DS302		G-84-E	LAMP:NEON	
DS303		AC4-10	LAMP:NEON AGED, SELECTED, DOT ON + LEAD	
DS304		2140-0008	LAMP GLOW NE-2 NEON	
DS305		G-84-E	LAMP:NEON	
DS306		2140-0006	LAMP GLOW NE-2 NEON	
DS307		G-84-E	LAMP:NEON	
DS308		2140-0008	LAMP GLOW NE-2 NEON	
DS309		G-84-E	LAMP:NEON	
DS310	THRU			
DS900			NOT ASSIGNED	
DS901		2140-0009	LAMP INCANDESCENT 6-8V .15 AMP	
F901		2110-0002	FUSE:CARTRIDGE 2 AMP 3 AG	
F902		2110-0023	FUSE:CARTRIDGE 6.25 AMP 250V SLOW BLOW	
F903		2110-0002	FUSE:CARTRIDGE 2 AMP 3 AG	
J101		1250-0118	CONNECTOR:BNC	
J102		G-76-D	CONNECTOR:FEMALE 9-PIN PC	
J103		G-76-D	CONNECTOR:FEMALE 9-PIN PC	
J104	THRU			
J200			NOT ASSIGNED	
J201		1250-0118	CONNECTOR:BNC	
J202		G-76-D	CONNECTOR:FEMALE 9-PIN PC	
J203	THRU			
J300			NOT ASSIGNED	
J301		1251-0006	CONNECTOR:MALE 16-CONTACT	
J302	THRU			
J600			NOT ASSIGNED	
J601		G-76-D	CONNECTOR:FEMALE 9-PIN PC	
J602	THRU			
J900			NOT ASSIGNED	
J901		G-76-D	CONNECTOR:FEMALE 9-PIN PC	
J902		G-76-D	CONNECTOR:FEMALE 9-PIN PC	
J903		1250-0118	CONNECTOR:BNC	
L201		524B-60G	COIL: 10.5UH	
L202		9140-0029	COIL:RF CHOKE 100UH 2.6 OHMS	
L203		9140-0029	COIL:RF CHOKE 100UH 2.6 OHMS	
L204		9140-0044	COIL VAR 165 UHY	
L205		9140-0009	COIL VAR RF 50-100 UHY	
L206		9140-0009	COIL VAR RF 50-100 UHY	
L207	THRU			
L300			NOT ASSIGNED	
L301		9140-0031	COIL FXD RF 75 UHY	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference		℗ Stock No.	Description	Note
L302		9140-0029	COIL:RF CHOKE 100UH 2.6 OHMS	
L303			NOT ASSIGNED	
L304		9140-0031	COIL FXD RF 75 UHY	
L305		9140-0029	COIL:RF CHOKE 100UH 2.6 OHMS	
L306		9140-0031	COIL FXD RF 75 UHY	
L307		9140-0029	COIL:RF CHOKE 100UH 2.6 OHMS	
L308		9140-0031	COIL FXD RF 75 UHY	
L309		9140-0029	COIL:RF CHOKE 100UH 2.6 OHMS	
L310	THRU			
L500			NOT ASSIGNED	
L501		9140-0027	COIL FXD RF 35 UHY	
L502		9140-0029	COIL:RF CHOKE 100UH 2.6 OHMS	
L503		9140-0027	COIL FXD RF 35 UHY	
L504		9140-0029	COIL:RF CHOKE 100UH 2.6 OHMS	
P301		1251-0007	CONNECTOR:FEMALE 16-PIN	
P302	THRU			
P700			NOT ASSIGNED	
P701		1251-0007	CONNECTOR:FEMALE 16-PIN	
P702	THRU			
P900			NOT ASSIGNED	
P901		8120-0015	CABLE:POWER	
R101		0687-4741	R:FXD COMP 470K OHMS 10% 1/2W	
R102		0687-3351	R:FXD COMP 3.3M OHMS 10% 1/2W	
R103		0687-4711	R:FXD COMP 470 OHMS 10% 1/2W	
R104		0727-0173	R:FXD DEPC 20K OHMS 1% 1/2W	
R105		0727-0216	R:FXD DEPC 136.7K OHM 1% 1/2W	
R106		0690-4721	R:FXD COMP 4700 OHMS 10% 1W	
R107		0690-4721	R:FXD COMP 4700 OHMS 10% 1W	
R108		2100-0044	R:VAR COMP 50K OHMS 10% 2W	
R109		0687-1031	R:FXD COMP 10K OHMS 10% 1/2W	
R110		0686-5645	R:FXD COMP 560K OHMS 5% 1/2W	
R111		0687-1531	R:FXD COMP 15K OHMS 10% 1/2W	
R112		2100-0093	R:VAR COMP 20K OHMS 20% LIN 1/5W	
R113		2100-0030	R:VAR COMP 250K 10% CWLOG 2W	
R114		2100-0154	R COMP 1000 OHM 30% LIN 3/10W	
R115		0727-0124	R:FXD DEPC 3000 OHMS 1% 1/2W	
R116		0767-0008	R:FXD MET FLM 10K OHMS 5% 3W	
R117		0763-0004	R:FXD MET FLM 23K OHMS 2% 2W	
R118		0690-3921	R:FXD COMP 3900 OHMS 10% 1W	
R119		0727-0218	R:FXD DEPC 180K OHM 1% 1/2W	
R120		0690-4721	R:FXD COMP 4700 OHMS 10% 1W	
R121		0687-4741	R:FXD COMP 470K OHMS 10% 1/2W	
R122		0727-0216	R:FXD DEPC 136.7K OHM 1% 1/2W	
R123		0687-1011	R:FXD COMP 100 OHMS 10% 1/2W	
R124		2100-0094	R:VAR COMP 50K OHMS 30% LIN 1/5W	
R125		0687-1851	R:FXD COMP 1.8M OHMS 10% 1/2W	
R126		0687-1021	R:FXD COMP 1000 OHMS 10% 1/2W	
R127		0687-1011	R:FXD COMP 100 OHMS 10% 1/2W	
R128		0687-2221	R:FXD COMP 2200 OHMS 10% 1/2W	
R129		0690-1041	R:FXD COMP 100K OHMS 10% 1W	
R130		0687-1041	R:FXD COMP 100K OHMS 10% 1/2W	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	Stock No.	Description	Note
R131 THRU R200		NOT ASSIGNED	
R201	0693-2731	R:FXD COMP 27K OHMS 10% 2W	
R202	0690-2231	R:FXD COMP 22K OHMS 10% 1W	
R203	0687-1051	R:FXD COMP 1M OHMS 10% 1/2W	
R204	2100-0095	R:VAR COMP 100K OHMS 30% LIN 1/5W	
R205	0687-1241	R:FXD COMP 120K OHMS 10% 1/2W ADJUSTABLE, AVERAGE VALUE SHOWN	
R206	0687-2241	R:FXD COMP 220K OHMS 10% 1/2W	
R207	0693-2721	R:FXD COMP 2700 OHMS 10% 2W	
R208	0693-3321	R:FXD COMP 3300 OHMS 10% 2W	
R209	0690-1521	R:FXD COMP 1500 OHMS 10% 1W	
R210	0727-0203	R:FXD DEPC 90K OHM 1% 1/2W	
R211	0727-0209	R:FXD DEPC 108K OHM 1% 1/2W	
R212	0687-2711	R:FXD COMP 270 OHMS +/-10% 1/2W	
R213	0690-2231	R:FXD COMP 22K OHMS 10% 1W	
R214	0687-2221	R:FXD COMP 2200 OHMS 10% 1/2W	
R215	0687-2711	R:FXD COMP 270 OHMS +/-10% 1/2W	
R216	0687-3931	R:FXD COMP 39K OHMS 10% 1/2W	
R217	0687-1011	R:FXD COMP 100 OHMS 10% 1/2W	
R218	0690-1041	R:FXD COMP 100K OHMS 10% 1W	
R219	0687-1021	R:FXD COMP 1000 OHMS 10% 1/2W	
R220	0690-5631	R:FXD COMP 56K OHMS 10% 1W	
R221	0687-8231	R:FXD COMP 82K OHMS 10% 1/2W	
R222	0687-1011	R:FXD COMP 100 OHMS 10% 1/2W	
R223	0687-4741	R:FXD COMP 470K OHMS 10% 1/2W	
R224	0687-1031	R:FXD COMP 10K OHMS 10% 1/2W	
R225	0727-0203	R:FXD DEPC 90K OHM 1% 1/2W	
R226	0727-0216	R:FXD DEPC 136.7K OHM 1% 1/2W	
R227	0689-1525	R:FXD COMP 1500 OHM 5% 1W	
R228	0689-1825	R:FXD COMP 1800 OHMS 5% 1W	
R229	0692-5125	R:FXD COMP 5100 OHMS 5% 2W	
R230	0687-2231	R:FXD COMP 22K OHMS 10% 1/2W	
R231		NOT ASSIGNED	
R232	0687-2231	R:FXD COMP 22K OHMS 10% 1/2W	
R233	0687-1011	R:FXD COMP 100 OHMS 10% 1/2W	
R234	0727-0203	R:FXD DEPC 90K OHM 1% 1/2W	
R235	0727-0216	R:FXD DEPC 136.7K OHM 1% 1/2W	
R236	0689-1525	R:FXD COMP 1500 OHM 5% 1W	
R237	0689-2225	R:FXD COMP 2200 OHM 5% 1W	
R238	0687-4721	R:FXD COMP 4700 OHMS 10% 1/2W	
R239	0687-4721	R:FXD COMP 4700 OHMS 10% 1/2W	
R240	0687-4741	R:FXD COMP 470K OHMS 10% 1/2W	
R241	0687-1011	R:FXD COMP 100 OHMS 10% 1/2W	
R242	0767-0011	R:FXD MET FLM 20K OHMS 5% 3W	
R243	0693-4721	R:FXD COMP 4700 OHMS 10% 2W	
R244	0687-1511	R:FXD COMP 150 OHMS 10% 1/2W	
R245	0687-1041	R:FXD COMP 100K OHMS 10% 1/2W	
R246	0687-1011	R:FXD COMP 100 OHMS 10% 1/2W	
R247	0687-1041	R:FXD COMP 100K OHMS 10% 1/2W	
R248	0687-1811	R:FXD COMP 180 OHMS 10% 1/2W	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	℗ Stock No.	Description	Note
R249	0687-6821	R:FXD COMP 6800 OHMS 10% 1/2W ADJUSTABLE; AVERAGE VALUE SHOWN	
R250	0693-4721	R:FXD COMP 4700 OHMS 10% 2W	
R251	0687-1011	R:FXD COMP 100 OHMS 10% 1/2W	
R252	0687-1041	R:FXD COMP 100K OHMS 10% 1/2W	
R253	0687-1811	R:FXD COMP 180 OHMS 10% 1/2W	
R254	0687-6821	R:FXD COMP 6800 OHMS 10% 1/2W	
R255	0693-2221	R:FXD COMP 2200 OHMS 10% 2W	
R256	0687-1021	R:FXD COMP 1000 OHMS 10% 1/2W	
R257	0693-1531	R:FXD COMP 15K OHMS 10% 2W	
R258	0687-1011	R:FXD COMP 100 OHMS 10% 1/2W	
R259	0687-1011	R:FXD COMP 100 OHMS 10% 1/2W	
R260	0690-4711	R:FXD COMP 470 OHMS 10% 1W	
R261	0687-1021	R:FXD COMP 1000 OHMS 10% 1/2W ADJUSTABLE; AVERAGE VALUE SHOWN	
R262	0687-1011	R:FXD COMP 100 OHMS 10% 1/2W	
R263	0687-1011	R:FXD COMP 100 OHMS 10% 1/2W	
R264	0687-1011	R:FXD COMP 100 OHMS 10% 1/2W	
R265	0687-3321	R:FXD COMP 3300 OHM 10% 1/2W	
R266	0687-1031	R:FXD COMP 10K OHMS 10% 1/2W	
R267	0687-1021	R:FXD COMP 1000 OHMS 10% 1/2W	
R268	0687-1041	R:FXD COMP 100K OHMS 10% 1/2W	
R269	0687-1041	R:FXD COMP 100K OHMS 10% 1/2W	
R270	0687-4721	R:FXD COMP 4700 OHMS 10% 1/2W	
R271	0687-1011	R:FXD COMP 100 OHMS 10% 1/2W ADJUSTABLE AVERAGE VALUE SHOWN	
R272	0687-1011	R:FXD COMP 100 OHMS 10% 1/2W	
R273	0690-1041	R:FXD COMP 100K OHMS 10% 1W	
R274	0690-1231	R:FXD COMP 12K OHMS 10% 1W	
R275	0687-1041	R:FXD COMP 100K OHMS 10% 1/2W ADJUSTABLE; AVERAGE VALUE SHOWN	
R276 THRU R301		NOT ASSIGNED	
R302	0770-0002	R:FXD MET FLM 2400 OHMS 5% 4W	
R303	0687-4731	R:FXD COMP 47K 10% 1/2W	
R304	2100-0094	R:VAR COMP 50K OHMS 30% LIN 1/5W	
R305		NOT ASSIGNED	
R306	0687-1041	R:FXD COMP 100K OHMS 10% 1/2W	
R307	0690-2721	R:FXD COMP 2700 OHMS 10% 1W	
R308	0692-1035	R:FXD COMP 10K OHMS 5% 2W	
R309	0687-2741	R:FXD COMP 270K OHMS 10% 1/2W	
R310	0687-3351	R:FXD COMP 3.3M OHMS 10% 1/2W	
R311	0686-9125	R:FXD COMP 9100 OHMS 5% 1/2W	
R312	0686-1045	R:FXD COMP 100K OHMS 5%1/2W	
R313	0686-9135	R:FXD COMP 91K OHMS 5% 1/2W	
R314	0686-1045	R:FXD COMP 100K OHMS 5%1/2W	
R315	0686-1045	R:FXD COMP 100K OHMS 5%1/2W	
R316	0686-1045	R:FXD COMP 100K OHMS 5%1/2W	
R317	0686-1045	R:FXD COMP 100K OHMS 5%1/2W	
R318	0686-1045	R:FXD COMP 100K OHMS 5%1/2W	
R319	0686-1045	R:FXD COMP 100K OHMS 5%1/2W	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	Stock No.	Description	Note
R320	0686-1045	R:FXD COMP 100K OHMS 5%1/2W	
R321	0686-1045	R:FXD COMP 100K OHMS 5%1/2W	
R322	0686-3325	R:FXD COMP 3300 OHMS 5% 1/2W	
R323	0686-3325	R:FXD COMP 3300 OHMS 5% 1/2W	
R324	0686-3325	R:FXD COMP 3300 OHMS 5% 1/2W	
R325	0686-3325	R:FXD COMP 3300 OHMS 5% 1/2W	
R326	0686-3325	R:FXD COMP 3300 OHMS 5% 1/2W	
R327	0686-3325	R:FXD COMP 3300 OHMS 5% 1/2W	
R328	0686-3325	R:FXD COMP 3300 OHMS 5% 1/2W	
R329	0686-3325	R:FXD COMP 3300 OHMS 5% 1/2W	
R330	0686-3325	R:FXD COMP 3300 OHMS 5% 1/2W	
R331	0686-3325	R:FXD COMP 3300 OHMS 5% 1/2W	
R332	0687-4731	R:FXD COMP 47K 10% 1/2W	
R333	0687-1041	R:FXD COMP 100K OHMS 10% 1/2W	
R334	0687-1041	R:FXD COMP 100K OHMS 10% 1/2W	
R335	0687-1231	R:FXD COMP 12K OHMS 10% 1/2W	
R336	0687-1031	R:FXD COMP 10K OHMS 10% 1/2W	
R337	0693-2731	R:FXD COMP 27K OHMS 10% 2W	
R338	0690-2221	R:FXD COMP 2200 OHMS 10% 1W	
R339	0687-4731	R:FXD COMP 47K 10% 1/2W	
R340	2100-0094	R:VAR COMP 50K OHMS 30% LIN 1/5W	
R341		NOT ASSIGNED	
R342	0687-1041	R:FXD COMP 100K OHMS 10% 1/2W	
R343	0690-2721	R:FXD COMP 2700 OHMS 10% 1W	
R344	0692-1035	R:FXD COMP 10K OHMS 5% 2W	
R345	0687-2741	R:FXD COMP 270K OHMS 10% 1/2W	
R346	0686-9125	R:FXD COMP 9100 OHMS 5% 1/2W	
R347	0686-9135	R:FXD COMP 91K OHMS 5% 1/2W	
R348	0686-1045	R:FXD COMP 100K OHMS 5%1/2W	
R349	0686-1045	R:FXD COMP 100K OHMS 5%1/2W	
R350	0686-1045	R:FXD COMP 100K OHMS 5%1/2W	
R351	0686-1045	R:FXD COMP 100K OHMS 5%1/2W	
R352	0686-1045	R:FXD COMP 100K OHMS 5%1/2W	
R353	0686-1045	R:FXD COMP 100K OHMS 5%1/2W	
R354	0686-1045	R:FXD COMP 100K OHMS 5%1/2W	
R355	0686-1045	R:FXD COMP 100K OHMS 5%1/2W	
R356	0686-1045	R:FXD COMP 100K OHMS 5%1/2W	
R357	0686-3325	R:FXD COMP 3300 OHMS 5% 1/2W	
R358	0686-3325	R:FXD COMP 3300 OHMS 5% 1/2W	
R359	0686-3325	R:FXD COMP 3300 OHMS 5% 1/2W	
R360	0686-3325	R:FXD COMP 3300 OHMS 5% 1/2W	
R361	0686-3325	R:FXD COMP 3300 OHMS 5% 1/2W	
R362	0686-3325	R:FXD COMP 3300 OHMS 5% 1/2W	
R363	0686-3325	R:FXD COMP 3300 OHMS 5% 1/2W	
R364	0686-3325	R:FXD COMP 3300 OHMS 5% 1/2W	
R365	0686-3325	R:FXD COMP 3300 OHMS 5% 1/2W	
R366	0686-3325	R:FXD COMP 3300 OHMS 5% 1/2W	
R367	0687-1041	R:FXD COMP 100K OHMS 10% 1/2W	
R368	0687-4731	R:FXD COMP 47K 10% 1/2W	
R369	0687-4731	R:FXD COMP 47K 10% 1/2W	
R370	0687-1231	R:FXD COMP 12K OHMS 10% 1/2W	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	Stock No.	Description	Note
R371	0687-2231	RESISTOR COMP 22K OHMS 10% 1/2W	
R372	0687-2231	RESISTOR COMP 22K OHMS 10% 1/2W	
R373	0687-1041	RESISTOR COMP 100K OHMS 10% 1/2W	
R374	0690-2221	RESISTOR COMP 2200 OHMS 10% 1W	
R375	0687-4731	RESISTOR COMP 47K 10% 1/2W	
R376	2100-0094	RESISTOR VAR COMP 50K OHMS 30% LIN 1/5W	
R377 THRU			
R378		NOT ASSIGNED	
R379	0690-2721	RESISTOR COMP 2700 OHMS 10% 1W	
R380	0692-1035	RESISTOR COMP 10K OHMS 5% 2W	
R381	0687-2741	RESISTOR COMP 270K OHMS 10% 1/2W	
R382	0686-9125	RESISTOR COMP 9100 OHMS 5% 1/2W	
R383	0686-9135	RESISTOR COMP 91K OHMS 5% 1/2W	
R384	0686-1045	RESISTOR COMP 100K OHMS 5%1/2W	
R385	0686-1045	RESISTOR COMP 100K OHMS 5%1/2W	
R386	0686-1045	RESISTOR COMP 100K OHMS 5%1/2W	
R387	0686-1045	RESISTOR COMP 100K OHMS 5%1/2W	
R388	0686-1045	RESISTOR COMP 100K OHMS 5%1/2W	
R389	0686-1045	RESISTOR COMP 100K OHMS 5%1/2W	
R390	0686-1045	RESISTOR COMP 100K OHMS 5%1/2W	
R391	0686-1045	RESISTOR COMP 100K OHMS 5%1/2W	
R392	0686-1045	RESISTOR COMP 100K OHMS 5%1/2W	
R393	0686-3325	RESISTOR COMP 3300 OHMS 5% 1/2W	
R394	0686-3325	RESISTOR COMP 3300 OHMS 5% 1/2W	
R395	0686-3325	RESISTOR COMP 3300 OHMS 5% 1/2W	
R396	0686-3325	RESISTOR COMP 3300 OHMS 5% 1/2W	
R397	0686-3325	RESISTOR COMP 3300 OHMS 5% 1/2W	
R398	0686-3325	RESISTOR COMP 3300 OHMS 5% 1/2W	
R399	0686-3325	RESISTOR COMP 3300 OHMS 5% 1/2W	
R400	0686-3325	RESISTOR COMP 3300 OHMS 5% 1/2W	
R401	0686-3325	RESISTOR COMP 3300 OHMS 5% 1/2W	
R402	0686-3325	RESISTOR COMP 3300 OHMS 5% 1/2W	
R403	0687-1041	RESISTOR COMP 100K OHMS 10% 1/2W	
R404	0687-1041	RESISTOR COMP 100K OHMS 10% 1/2W	
R405	0687-1041	RESISTOR COMP 100K OHMS 10% 1/2W	
R406	0687-1231	RESISTOR COMP 12K OHMS 10% 1/2W	
R407	0687-3331	RESISTOR COMP 33K OHMS 10% 1/2W	
R408	0687-3331	RESISTOR COMP 33K OHMS 10% 1/2W	
R409	0687-3331	RESISTOR COMP 33K OHMS 10% 1/2W	
R410 THRU			
R411		NOT ASSIGNED	
R412	0690-4731	RESISTOR COMP 47K OHMS 10% 1W	
R413	0690-2221	RESISTOR COMP 2200 OHMS 10% 1W	
R414	0687-4731	RESISTOR COMP 47K 10% 1/2W	
R415	2100-0094	RESISTOR VAR COMP 50K OHMS 30% LIN 1/5W	
R416		NOT ASSIGNED	
R417	0687-1041	RESISTOR COMP 100K OHMS 10% 1/2W	
R418	0690-2721	RESISTOR COMP 2700 OHMS 10% 1W	
R419	0692-1035	RESISTOR COMP 10K OHMS 5% 2W	
R420	0687-2741	RESISTOR COMP 270K OHMS 10% 1/2W	
R421	0686-9125	RESISTOR COMP 9100 OHMS 5% 1/2W	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	Stock No.	Description	Note
R422	0686-9135	R:FXD COMP 91K OHMS 5% 1/2W	
R423	0686-1045	R:FXD COMP 100K OHMS 5%1/2W	
R424	0686-1045	R:FXD COMP 100K OHMS 5%1/2W	
R425	0686-1045	R:FXD COMP 100K OHMS 5%1/2W	
R426	0686-1045	R:FXD COMP 100K OHMS 5%1/2W	
R427	0686-1045	R:FXD COMP 100K OHMS 5%1/2W	
R428	0686-1045	R:FXD COMP 100K OHMS 5%1/2W	
R429	0686-1045	R:FXD COMP 100K OHMS 5%1/2W	
R430	0686-1045	R:FXD COMP 100K OHMS 5%1/2W	
R431	0686-1045	R:FXD COMP 100K OHMS 5%1/2W	
R432	0686-3325	R:FXD COMP 3300 OHMS 5% 1/2W	
R433	0686-3325	R:FXD COMP 3300 OHMS 5% 1/2W	
R434	0686-3325	R:FXD COMP 3300 OHMS 5% 1/2W	
R435	0686-3325	R:FXD COMP 3300 OHMS 5% 1/2W	
R436	0686-3325	R:FXD COMP 3300 OHMS 5% 1/2W	
R437	0686-3325	R:FXD COMP 3300 OHMS 5% 1/2W	
R438	0686-3325	R:FXD COMP 3300 OHMS 5% 1/2W	
R439	0686-3325	R:FXD COMP 3300 OHMS 5% 1/2W	
R440	0686-3325	R:FXD COMP 3300 OHMS 5% 1/2W	
R441	0686-3325	R:FXD COMP 3300 OHMS 5% 1/2W	
R442	0687-1041	R:FXD COMP 100K OHMS 10% 1/2W	
R443	0687-1041	R:FXD COMP 100K OHMS 10% 1/2W	
R444	0690-1031	R:FXD COMP 10K OHMS 10% 1W	
R445	0690-1031	R:FXD COMP 10K OHMS 10% 1W	
R446		NOT ASSIGNED	
R447	0687-1011	R:FXD COMP 100 OHMS 10% 1/2W	
R448	0687-5611	R:FXD COMP 560 OHMS 10% 1/2W	
R449	0687-1011	R:FXD COMP 100 OHMS 10% 1/2W	
R450	0687-5611	R:FXD COMP 560 OHMS 10% 1/2W	
R451	0687-1011	R:FXD COMP 100 OHMS 10% 1/2W	
R452	0687-5611	R:FXD COMP 560 OHMS 10% 1/2W	
R453	0687-1011	R:FXD COMP 100 OHMS 10% 1/2W	
R454	0818-0010	R:FXD WW 2000 OHMS 5% 30W	
R455	0687-1041	R:FXD COMP 100K OHMS 10% 1/2W	
R456	0687-1031	R:FXD COMP 10K OHMS 10% 1/2W	
R457	0687-1041	R:FXD COMP 100K OHMS 10% 1/2W	
R458	0687-1031	R:FXD COMP 10K OHMS 10% 1/2W	
R459	0687-1041	R:FXD COMP 100K OHMS 10% 1/2W	
R460	0687-1031	R:FXD COMP 10K OHMS 10% 1/2W	
R461	0687-1011	R:FXD COMP 100 OHMS 10% 1/2W	
R462	0687-1011	R:FXD COMP 100 OHMS 10% 1/2W	
R463 THRU R500		NOT ASSIGNED	
R501	0687-5611	R:FXD COMP 560 OHMS 10% 1/2W	
R502	0687-1011	R:FXD COMP 100 OHMS 10% 1/2W ADJUSTABLE, AVERAGE VALUE SHOWN	
R503	0693-4731	R:FXD COMP 47K OHMS 10% 2W	
R504	0687-1241	R:FXD COMP 120K OHMS 10% 1/2W	
R505	0687-1521	R:FXD COMP 1500 OHMS 10% 1/2W	
R506	0687-1541	R:FXD COMP 150K OHMS 10% 1/2W	
R507	0771-0003	R:FXD MET FLM 5000 OHMS 10% 4W	

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Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	℗ Stock No.	Description	Note
R508	0687-5611	RESISTOR COMP 560 OHMS 10% 1/2W	
R509	0690-1531	RESISTOR COMP 15K OHMS 10% 1W	
R510	0690-3921	RESISTOR COMP 3900 OHMS 10% 1W	
R511	2100-0177	RESISTOR VAR DUAL 2X100K 20% LIN 2W	
R512	2100-0094	RESISTOR VAR COMP 50K OHMS 30% LIN 1/5W	
R513	0687-1231	RESISTOR COMP 12K OHMS 10% 1/2W	
R514	0687-3311	RESISTOR COMP 330 OHMS 10% 1/2W	
R515	0687-5611	RESISTOR COMP 560 OHMS 10% 1/2W	
R516	0687-1011	RESISTOR COMP 100 OHMS 10% 1/2W ADJUSTABLE, AVERAGE VALUE SHOWN	
R517	0693-4731	RESISTOR COMP 47K OHMS 10% 2W	
R518	0687-1241	RESISTOR COMP 120K OHMS 10% 1/2W	
R519	0687-1521	RESISTOR COMP 1500 OHMS 10% 1/2W	
R520	0687-1541	RESISTOR COMP 150K OHMS 10% 1/2W	
R521	0771-0003	RESISTOR MET FLM 5000 OHMS 10% 4W	
R522	0687-5611	RESISTOR COMP 560 OHMS 10% 1/2W	
R523	0690-1531	RESISTOR COMP 15K OHMS 10% 1W	
R524	0690-3921	RESISTOR COMP 3900 OHMS 10% 1W	
R525		NOT ASSIGNED	
R526	2100-0094	RESISTOR VAR COMP 50K OHMS 30% LIN 1/5W	
R527	0687-1231	RESISTOR COMP 12K OHMS 10% 1/2W	
R528	0687-3311	RESISTOR COMP 330 OHMS 10% 1/2W	
R529	0687-1011	RESISTOR COMP 100 OHMS 10% 1/2W	
R530	0687-1011	RESISTOR COMP 100 OHMS 10% 1/2W	
R531	0687-2711	RESISTOR COMP 270 OHMS +/-10% 1/2W ADJUSTABLE, AVERAGE VALUE SHOWN	
R532	0687-2711	RESISTOR COMP 270 OHMS +/-10% 1/2W	
R533 THRU R600		NOT ASSIGNED	
R601	0727-0217	RESISTOR DEPC 140K OHM 1% 1/2W	
R602	0687-1011	RESISTOR COMP 100 OHMS 10% 1/2W	
R603	0727-0218	RESISTOR DEPC 180K OHM 1% 1/2W	
R604	0693-2231	RESISTOR COMP 22K OHMS 10% 2W	
R605	0686-1235	RESISTOR COMP 12K OHMS 5%1/2W	
R606	0687-1011	RESISTOR COMP 100 OHMS 10% 1/2W	
R607	0727-0216	RESISTOR DEPC 136.7K OHM 1% 1/2W	
R608	0727-0216	RESISTOR DEPC 136.7K OHM 1% 1/2W	
R609	0727-0216	RESISTOR DEPC 136.7K OHM 1% 1/2W	
R610	0727-0216	RESISTOR DEPC 136.7K OHM 1% 1/2W	
R611	0687-1011	RESISTOR COMP 100 OHMS 10% 1/2W	
R612	0693-2231	RESISTOR COMP 22K OHMS 10% 2W	
R613	0686-1235	RESISTOR COMP 12K OHMS 5%1/2W	
R614	0687-1011	RESISTOR COMP 100 OHMS 10% 1/2W	
R615	0727-0217	RESISTOR DEPC 140K OHM 1% 1/2W	
R616	0727-0218	RESISTOR DEPC 180K OHM 1% 1/2W	
R617	0693-8231	RESISTOR COMP 82K OHMS 10% 2W	
R618	0687-4711	RESISTOR COMP 470 OHMS 10% 1/2W	
R619	0687-5641	RESISTOR COMP 560K OHMS 10% 1/2W	
R620 THRU R621		NOT ASSIGNED	
R622	0730-0072	RESISTOR DEPC 1.3K OHMS 1% 1W	

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Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	Stock No.	Description	Note
R623	0727-0170	R:FXD DEPC 18K OHMS 1% 1/2W	
R624	0699-2221	R:FXD COMP 2200 OHMS 10% 2W	
R625		NOT ASSIGNED	
R626	0687-4701	R:FXD COMP 47 OHMS 10% 1/2W	
R627	2100-0144	R:VAR COMP 250K OHM 30% LIN 1/5W	
R628		NOT ASSIGNED	
R629	0687-1041	R:FXD COMP 100K OHMS 10% 1/2W ADJUSTABLE, AVERAGE VALUE SHOWN	
R630	0686-1245	R:FXD COMP 120K OHMS 5%1/2W	
R631	0687-5641	R:FXD COMP 560K OHMS 10% 1/2W	
R632	0687-4701	R:FXD COMP 47 OHMS 10% 1/2W	
R633	0687-4701	R:FXD COMP 47 OHMS 10% 1/2W	
R634		NOT ASSIGNED	
R635	0687-5601	R:FXD COMP 56 OHMS 10% 1/2W	
R636	0687-4711	R:FXD COMP 470 OHMS 10% 1/2W	
R637	0686-1245	R:FXD COMP 120K OHMS 5%1/2W	
R638	0686-1245	R:FXD COMP 120K OHMS 5%1/2W	
R639	0686-8235	R:FXD COMP 82K OHMS 5% 1/2W	
R640	0686-8235	R:FXD COMP 82K OHMS 5% 1/2W	
R641 THRU R900		NOT ASSIGNED	
R901	0690-1041	R:FXD COMP 100K OHMS 10% 1W	
R902	0690-1041	R:FXD COMP 100K OHMS 10% 1W	
R903	0818-0012	R:FXD WW 4500 OHM 5% 40W	
R904	0687-2241	R:FXD COMP 220K OHMS 10% 1/2W	
R905	0687-1551	R:FXD COMP 1.5M OHMS 10% 1/2W	
R906	0687-3931	R:FXD COMP 39K OHMS 10% 1/2W	
R907	0687-3951	R:FXD COMP 3.9M OHMS 10% 1/2W	
R908	0687-3301	R:FXD COMP 33 OHMS 10% 1/2W	
R909	0687-1011	R:FXD COMP 100 OHMS 10% 1/2W	
R910	0687-3301	R:FXD COMP 33 OHMS 10% 1/2W	
R911	0687-1011	R:FXD COMP 100 OHMS 10% 1/2W	
R912	0687-4741	R:FXD COMP 470K OHMS 10% 1/2W	
R913	0687-3301	R:FXD COMP 33 OHMS 10% 1/2W	
R914	0687-1011	R:FXD COMP 100 OHMS 10% 1/2W	
R915	0730-0075	R:FXD DEPC 160K OHMS 1% 1W ADJUSTABLE, AVERAGE VALUE SHOWN	
R916		NOT ASSIGNED	
R917	0730-0077	R:FXD DEPC 181K OHMS 1% 1W	
R918	0687-1011	R:FXD COMP 100 OHMS 10% 1/2W	
R919	0687-2711	R:FXD COMP 270 OHMS +/-10% 1/2W	
R920	0687-1011	R:FXD COMP 100 OHMS 10% 1/2W	
R921	0687-2241	R:FXD COMP 220K OHMS 10% 1/2W	
R922	0687-3951	R:FXD COMP 3.9M OHMS 10% 1/2W	
R923	0687-1551	R:FXD COMP 1.5M OHMS 10% 1/2W	
R924	0687-3931	R:FXD COMP 39K OHMS 10% 1/2W	
R925	0687-3301	R:FXD COMP 33 OHMS 10% 1/2W	
R926	0687-1011	R:FXD COMP 100 OHMS 10% 1/2W	
R927		NOT ASSIGNED	
R928	0687-1041	R:FXD COMP 100K OHMS 10% 1/2W	
R929	0687-4741	R:FXD COMP 470K OHMS 10% 1/2W	

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Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	℗ Stock No.	Description	Note
R930	0811-0006	R:FXD WW 5000 OHMS 1% 5W	
R931	0730-0085	R:FXD DEPC 316K OHMS 1% 1W	
R932		NOT ASSIGNED	
R933	0730-0079	R:FXD DEPC 216.3K OHMS 1% 1W	
R934	0690-1041	R:FXD COMP 100K OHMS 10% 1W	
R935	0818-0014	R:FXD WW 1000 OHMS 5% 40W	
R936	0690-6231	R:FXD COMP 62K OHMS 10% 1W	
R937	0687-2241	R:FXD COMP 220K OHMS 10% 1/2W	
R938	0690-3931	R:FXD COMP 39K OHMS 10% 1W	
R939	0687-3951	R:FXD COMP 3.9M OHMS 10% 1/2W	
R940	0687-3301	R:FXD COMP 33 OHMS 10% 1/2W	
R941	0687-1011	R:FXD COMP 100 OHMS 10% 1/2W	
R942	0687-1011	R:FXD COMP 100 OHMS 10% 1/2W	
R943	0687-3301	R:FXD COMP 33 OHMS 10% 1/2W	
R944	0687-1021	R:FXD COMP 1000 OHMS 10% 1/2W	
R945	0690-4731	R:FXD COMP 47K OHMS 10% 1W	
R946	0687-1011	R:FXD COMP 100 OHMS 10% 1/2W	
R947	0687-3301	R:FXD COMP 33 OHMS 10% 1/2W	
R948	0687-4741	R:FXD COMP 470K OHMS 10% 1/2W	
R949	0687-1541	R:FXD COMP 150K OHMS 10% 1/2W	
R950	2100-0094	R:VAR COMP 50K OHMS 30% LIN 1/5W	
R951	0687-2241	R:FXD COMP 220K OHMS 10% 1/2W	
R952	0687-1011	R:FXD COMP 100 OHMS 10% 1/2W	
R953	0687-1841	R:FXD COMP 180K OHMS 10% 1/2W	
R954	2100-0094	R:VAR COMP 50K OHMS 30% LIN 1/5W	
R955	0687-1841	R:FXD COMP 180K OHMS 10% 1/2W	
R956	0690-2741	R:FXD COMP 270K OHMS 10% 1W	
R957	0690-1551	R:FXD COMP 1.5M OHMS 10% 1W	
R958	0687-1251	R:FXD COMP 1.2M OHMS 10% 1/2W	
R959	0687-1251	R:FXD COMP 1.2M OHMS 10% 1/2W	
R960	0687-4711	R:FXD COMP 470 OHMS 10% 1/2W	
R961	0687-4711	R:FXD COMP 470 OHMS 10% 1/2W	
R962	0690-3301	R:FXD COMP 33 OHMS 10% 1W	
R963	0687-4711	R:FXD COMP 470 OHMS 10% 1/2W	
R964	0687-2211	R:FXD COMP 220 OHMS 10% 1/2W	
R965	0687-4721	R:FXD COMP 4700 OHMS 10% 1/2W	
R966	0687-4721	R:FXD COMP 4700 OHMS 10% 1/2W	
R967	0687-4721	R:FXD COMP 4700 OHMS 10% 1/2W	
RT901	0839-0006	RT: 10 OHMS 10%	
RT902	0839-0006	RT: 10 OHMS 10%	
S101	3100-0178	SWITCH-ROTARY: 5 POS 1 SECT	
S102	3101-0014	SWITCH PUSHBUTTON SPST BREAK BEFORE MAKE	
S103 THRU S200		NOT ASSIGNED	
S201	3101-0005	SWITCH TOG DPDT JAN #ST22N	
S202	3101-0011	SWITCH SLIDE DPDT 0.5 AMP 125 VDC	
S203 THRU S300		NOT ASSIGNED	
S301	3100-0179	SWITCH-ROTARY: DUAL CONCENTRIC 10 POS	
S302	3100-0179	SWITCH-ROTARY: DUAL CONCENTRIC 10 POS	

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Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference		℗ Stock No.	Description	Note
S303		3100-0179	SWITCH-ROTARY: DUAL CONCENTRIC 10 POS	
S304		3100-0179	SWITCH-ROTARY: DUAL CONCENTRIC 10 POS	
S305	THRU			
S900			NOT ASSIGNED	
S901		3101-0017	SWITCH TOG DPDT 10 AMP 250V	
S902		3100-0147	SWITCH-LEVER: 3 POS	
T101		218A-60B	TRANSFORMER:PULSE RED	
T102		218A-60C	TRANSFORMER:PULSE YELLOW	
T103	THRU			
T200			NOT ASSIGNED	
T201		218A-60E	TRANSFORMER:PULSE GREEN	
T202		218A-60E	TRANSFORMER:PULSE GREEN	
T203	THRU			
T300			NOT ASSIGNED	
T301		218A-60D	TRANSFORMER:PULSE GREY	
T302		218A-60D	TRANSFORMER:PULSE GREY	
T303		218A-60D	TRANSFORMER:PULSE GREY	
T304	THRU			
T500			NOT ASSIGNED	
T501		218A-60C	TRANSFORMER:PULSE YELLOW	
T502		218A-60C	TRANSFORMER:PULSE YELLOW	
T503	THRU			
T600			NOT ASSIGNED	
T601		9130-0008	TRANSFORMER:PULSE	
T602	THRU			
T900			NOT ASSIGNED	
T901		9100-0100	T POWER	
T902		9100-0099	T POWER	
T903		9130-0008	TRANSFORMER:PULSE	
TC901		3103-0007	SWITCH: THERMOSTAT SPDT	
V101		1932-0009	TUBE:ELECTRON 5965	
V102		1932-0009	TUBE:ELECTRON 5965	
V103		1923-0002	ELECTRON TUBE: 5725 PENTODE	
V104	THRU			
V200			NOT ASSIGNED	
V201		1932-0023	ELECTRON TUBE: 6J6 DOUBLE TRIODE	
V202		1923-0001	ELECTRON TUBE: 5654 PENTODE HP	
V203		1923-0001	ELECTRON TUBE: 5654 PENTODE HP	
V204		1923-0002	ELECTRON TUBE: 5725 PENTODE	
V205		1932-0009	TUBE:ELECTRON 5965	
V206		1932-0009	TUBE:ELECTRON 5965	
V207		1923-0002	ELECTRON TUBE: 5725 PENTODE	
V208		1923-0017	ELECTRON TUBE: 6AH6 PENTODE	
V209		1923-0017	ELECTRON TUBE: 6AH6 PENTODE	
V210		1932-0009	TUBE:ELECTRON 5965	
V211	THRU			
V300			NOT ASSIGNED	
V301		1933-0003	ELECTRON TUBE: 6BH8 TRIODE PENTODE	
V302		1970-0003	TYPE 6700 MAGNETIC BEAM SWITCHING TUBE	
V303		1932-0008	ELECTRON TUBE: TWIN TRIODE 9 PIN MINIAT	

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Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference		Stock No.	Description	Note
V304		1932-0006	ELECTRON TUBE: TWIN TRIODE 9 PIN MINIAT	
V305		1923-0002	ELECTRON TUBE: 5725 PENTODE	
V306		1933-0003	ELECTRON TUBE: 6BH8 TRIODE PENTODE	
V307		1970-0003	TYPE 6700 MAGNETIC BEAM SWITCHING TUBE	
V308		1923-0002	ELECTRON TUBE: 5725 PENTODE	
V309		1933-0003	ELECTRON TUBE: 6BH8 TRIODE PENTODE	
V310		1970-0003	TYPE 6700 MAGNETIC BEAM SWITCHING TUBE	
V311		1932-0006	ELECTRON TUBE: TWIN TRIODE 9 PIN MINIAT	
V312		1932-0006	ELECTRON TUBE: TWIN TRIODE 9 PIN MINIAT	
V313		1923-0002	ELECTRON TUBE: 5725 PENTODE	
V314		1923-0017	ELECTRON TUBE: 6AH6 PENTODE	
V315		1970-0003	TYPE 6700 MAGNETIC BEAM SWITCHING TUBE	
V316	THRU			
V500			NOT ASSIGNED	
V501		1923-0002	ELECTRON TUBE: 5725 PENTODE	
V502		1932-0009	TUBE:ELECTRON 5965	
V503		1923-0002	ELECTRON TUBE: 5725 PENTODE	
V504		1932-0009	TUBE:ELECTRON 5965	
V505	THRU			
V600			NOT ASSIGNED	
V601		1932-0027	ELECTRON TUBE: 12AT7 DUAL TRIODE	
V602		1932-0027	ELECTRON TUBE: 12AT7 DUAL TRIODE	
V603		1932-0016	ELECTRON TUBE: 7119 DUAL TRIODE	
V604	THRU			
V900			NOT ASSIGNED	
V901		1921-0010	ELECTRON TUBE: 12B4A TRIODE 9 PIN MIN	
V902		1921-0010	ELECTRON TUBE: 12B4A TRIODE 9 PIN MIN	
V903		1921-0010	ELECTRON TUBE: 12B4A TRIODE 9 PIN MIN	
V904		1923-0028	ELECTRON TUBE: 6CB6A PENTODE	
V905		1921-0010	ELECTRON TUBE: 12B4A TRIODE 9 PIN MIN	
V906		1923-0028	ELECTRON TUBE: 6CB6A PENTODE	
V907		1932-0009	TUBE:ELECTRON 5965	
V908		1921-0010	ELECTRON TUBE: 12B4A TRIODE 9 PIN MIN	
V909		1921-0010	ELECTRON TUBE: 12B4A TRIODE 9 PIN MIN	
V910		1921-0010	ELECTRON TUBE: 12B4A TRIODE 9 PIN MIN	
V911		1933-0004	ELECTRON TUBE: 6U8 OR 6U8A TRIODE PENTODE	
V912		1940-0001	ELECTRON TUBE: 5651 VOLTAGE REFERENCE	
V913		1932-0030	ELECTRON TUBE: 12AX7 DUAL TRIODE	
V914		1921-0010	ELECTRON TUBE: 12B4A TRIODE 9 PIN MIN	
Y201		0410-0012	CRYSTAL: 1MC +/-0.001%	
			MISCELLANEOUS	
		G-74H	KNOB:PULSE RATE	
		G-74BF	KNOB:MICROSECOND DELAY T2(1/10)	
		G-74N	KNOB:START PULSE SELECTOR	
		G-74BM	KNOB:MICROSECOND DELAY T1.	
		G-74BD	KNOB:MICROSECOND DELAY T2.	
		G-74AA	KNOB:SYNC OUTPUT	
		3150-0002	OIL:AIR FL.WATER SOLUABLE OIL	
		1450-0027	LAMPHOLDER:BAYONET	
		218A-40C	DIAL ASSBY	
		3150-0009	FL AIR 10 X 10 X 7/8	
		1400-0007	FUSEHOLDER	

See introduction to this section

Table 6-2. Replaceable Parts

Stock No.	Description	Mfr.	Mfr. Part No.	TQ	RS		
0130-0001	C:VAR CER 7-45 PF N500	72982	503 000 02P0-33R	1	1		
0130-0003	C:VAR C 1.5-7PF 500VDCW	72982	503-000C0P0-10R	1	1		
0130-0006	C:VAR CER 5-20PF N300	28480	0130-0006	1	1		
0130-0015	C:VAR CER 9-50 PF N750	72982	3192-000-U2P0-47R	1	1		
0131-0004	C:VAR MICA 16-150 PF 175VDCW	28480	0131 0004	2	1		
0140-0004	C:FXD MICA 15 PF 10% 500VDCW	00853	TYPE DR DR1415 B10	15	3		
0140-0024	C:FXD MICA 2200 PF 10% 500 VDCW	00853	TYPE C C1222 B10	13	3		
0140-0025	C:FXD MICA 68 PF 10% 500 VDCW	76433	RCM15B680K	2	1		
0140-0026	C:FXD MICA 22 PF 10% 500 VDCW	76433	RCM20B220K	1	1		
0140-0027	C:FXD MICA 470 PF 10% 500 VDCW	00853	TYPE K K1347 B10	1	1		
0140-0030	C:FXD MICA 390 PF 10% 500 VDCW	00853	TYPE K K1339 B10	8	2		
0140-0032	C:FXD MICA 47 PF 10% 500 VDCW	00853	TYPE K K1447 B10	1	1		
0140-0034	C:FXD MICA 22 PF 5% 500 VDCW	76433	RCM15E220J	2	1		
0140-0036	C:FXD MICA 110 PF 5% 500 VDCW	04062	CM15E111J	2	1		
0140-0037	C:FXD MICA 390 PF 5% 500 VDCW	00853	TYPE RR RR1339E5	7	2		
0140-0039	C:FXD MICA 47 PF 5% 500 VDCW	14655	CM15E470J	9	2		
0140-0040	C:FXD MICA 75 PF 5% 500 VDCW	00853	TYPE DR DR1475 E5	1	1		
0140-0042	C:FXD MICA 27 PF 5% 500 VDCW	00853	TYPE DR DR1427 E5	2	1		
0140-0054	C:FXD MICA 100 PF 10% 500 VDCW	00853	TYPE K K1310 B10	2	1		
0140-0055	C:FXD MICA 150 PF 10% 500 VDCW	76433	RCM20B151K	1	1		
0140-0081	C:FXD MICA 56PF +/-1PF	00853	DR1456E	1	1		
0140-0083	C:FXD MICA 220 PF 5% 500 VDCW	00853	TYPE DR DR1322 E5	1	1		
0140-0092	C:FXD MICA 240 PF 5% 500 VDCW	00853	TYPE DR DR1324 E5	1	1		
0140-0101	C:FXD MICA 15PF 5% 500 VDCW	00853	RCM15C150J	1	1		
0140-0139	C:FXD MICA 470 PF 10% 300 VDCW	76433	MCM15D471K	1	1		
0140-0193	C:FXD MICA 15PF 5% 500 VDCW	00853	RCM15C150J	2	1		
0150-0009	C:FXD CER 10PF +/-0.5PF NPO 500VDCW	04222	TYPE C1 1	5	1		
0150-0012	C:FXD CER 0.01UF 20% 1000VDCW	56289	H 1038	8	2		
0150-0014	C:FXD CER 5000PF MIN 500VDCW	04222	D1 4	5	1		
0150-0019	C:FXD CER 1000PF 20%	72982	327005X5U0102M	2	1		
0150-0023	C:FXD CER 2000PF 20% 1000VDCW	91418	TYPE JF .002 20%	1	1		
0150-0047	C:FXD TI 6.8 PF 10% 500 VDCW	78488	TYPE GA	1	1		
0150-0052	C:FXD 0.05 UF 20% 400 VDCW	05729	20X503MC4	3	1		
0150-0073	C:FXD CER 100 PF 10% 500 VDCW	56289	40C200A2	1	1		
0150-0075	C:FXD CER 4700 PF +100%-20% 500 V	19701	STYLE 851 EIA	1	1		
0160-0001	C:FXD MY 0.1UF 10% 600VDCW	56289	160P10496	1	1		
0160-0129	C:FXD MY 2200PF 2% 600VDCW	11711	107F222G	1	1		
0160-0130	C:FXD MY 2200PF 2% 600VDCW	11711	107F223G	1	1		
0160-0131	C:FXD MY 0.22UF 2% 600VDCW	11711	107F224G	1	1		
0170-0022	C:FXD MY 0.1UF 20% 600VDCW	09134	TYPE 27	26	6		
0180-0020	C:FXD ELECT 80UF -20/+100% 450VDCW	14655	KP10202ISSO	8	2		
0180-0051	C:FXD ELECT 8UF 350VDCW	56289	D32551	2	1		
0410-0012	CRYSTAL: 1MC +/-0.001%	00136	OBD	1	1		
0686-1045	R:FXD COMP 100K OHMS 5%1/2W	01121	EB-1045	36	8		
0686-1235	R:FXD COMP 12K OHMS 5%1/2W	01121	EB-1235	2	1		
0686-1245	R:FXD COMP 120K OHMS 5%1/2W	01121	EB-1245	3	1		
0686-3325	R:FXD COMP 3300 OHMS 5% 1/2W	01121	EB 3325	40	8		
0686-5645	R:FXD COMP 560K OHMS 5% 1/2W	01121	EB 5645	1	1		
0686-8235	R:FXD COMP 82K OHMS 5% 1/2W	01121	EB 8235	2	1		
0686-9125	R:FXD COMP 9100 OHMS 5% 1/2W	01121	EB 9125	4	1		

See introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

Stock No.	Description	Mfr.	Mfr. Part No.	TQ	RS		
0686-9135	R:FXD COMP 91K OHMS 5% 1/2W	01121	EB 9135	4	1		
0687-1011	R:FXD COMP 100 OHMS 10% 1/2W	01121	EB 1011	39	8		
0687-1021	R:FXD COMP 1000 OHMS 10% 1/2W	01121	EB 1021	6	2		
0687-1031	R:FXD COMP 10K OHMS 10% 1/2W	01121	EB 1031	7	2		
0687-1041	R:FXD COMP 100K OHMS 10% 1/2W	01121	EB 1041	24	5		
0687-1051	R:FXD COMP 1M OHMS 10% 1/2W	01121	EB 1051	1	1		
0687-1231	R:FXD COMP 12K OHMS 10% 1/2W	01121	EB 1231	5	1		
0687-1241	R:FXD COMP 120K OHMS 10% 1/2W	01121	EB 1241	3	1		
0687-1251	R:FXD COMP 1.2M OHMS 10% 1/2W	01121	EB 1251	2	1		
0687-1511	R:FXD COMP 150 OHMS 10% 1/2W	01121	EB 1511	1	1		
0687-1521	R:FXD COMP 1500 OHMS 10% 1/2W	01121	EB 1521	2	1		
0687-1531	R:FXD COMP 15K OHMS 10% 1/2W	01121	EB 1531	1	1		
0687-1541	R:FXD COMP 150K OHMS 10% 1/2W	01121	EB 1541	3	1		
0687-1551	R:FXD COMP 1.5M OHMS 10% 1/2W	01121	EB 1551	2	1		
0687-1811	R:FXD COMP 180 OHMS 10% 1/2W	01121	EB 1811	2	1		
0687-1841	R:FXD COMP 180K OHMS 10% 1/2W	01121	EB 1841	2	1		
0687-1851	R:FXD COMP 1.8M OHMS 10% 1/2W	01121	EB 1851	1	1		
0687-2211	R:FXD COMP 220 OHMS 10% 1/2W	01121	EB 2211	1	1		
0687-2221	R:FXD COMP 2200 OHMS 10% 1/2W	01121	EB 2221	2	1		
0687-2231	R:FXD COMP 22K OHMS 10% 1/2W	01121	EB 2231	4	1		
0687-2241	R:FXD COMP 220K OHMS 10% 1/2W	01121	EB 2241	5	1		
0687-2711	R:FXD COMP 270 OHMS +/-10% 1/2W	01121	EB2711	5	1		
0687-2741	R:FXD COMP 270K OHMS 10% 1/2W	01121	EB-2741	4	1		
0687-3301	R:FXD COMP 33 OHMS 10% 1/2W	01121	EB 3301	7	2		
0687-3311	R:FXD COMP 330 OHMS 10% 1/2W	01121	EB 3311	2	1		
0687-3321	R:FXD COMP 3300 OHM 10% 1/2W			1	1		
0687-3331	R:FXD COMP 33K OHMS 10% 1/2W	01121	EB 3331	3	1		
0687-3351	R:FXD COMP 3.3M OHMS 10% 1/2W	01121	EB 335	2	1		
0687-3931	R:FXD COMP 39K OHMS 10% 1/2W	01121	EB 3931	3	1		
0687-3951	R:FXD COMP 3.9M OHMS 10% 1/2W	01121	EB 3951	3	1		
0687-4701	R:FXD COMP 47 OHMS 10% 1/2W	01121	EB 4701	3	1		
0687-4711	R:FXD COMP 470 OHMS 10% 1/2W	01121	EB 4711	6	2		
0687-4721	R:FXD COMP 4700 OHMS 10% 1/2W	01121	EB 4721	6	2		
0687-4731	R:FXD COMP 47K 10% 1/2W	73506	EB4731	7	2		
0687-4741	R:FXD COMP 470K OHMS 10% 1/2W	01121	EB 4741	7	2		
0687-5601	R:FXD COMP 56 OHMS 10% 1/2W	01121	EB 5601	1	1		
0687-5611	R:FXD COMP 560 OHMS 10% 1/2W	01121	EB 5611	7	2		
0687-5641	R:FXD COMP 560K OHMS 10% 1/2W	01121	EB 5641	2	1		
0687-6821	R:FXD COMP 6800 OHMS 10% 1/2W	01121	EB 6821	2	1		
0687-8231	R:FXD COMP 82K OHMS 10% 1/2W	01121	EB 8231	1	1		
0689-1525	R:FXD COMP 1500 OHM 5% 1W	01121	GB 1525	2	1		
0689-1825	R:FXD COMP 1800 OHMS 5% 1W	01121	GB 1825	1	1		
0689-2225	R:FXD COMP 2200 OHM 5% 1W	01121	GB 2225	1	1		
0690-1031	R:FXD COMP 10K OHMS 10% 1W	01121	GB 1031	2	1		
0690-1041	R:FXD COMP 100K OHMS 10% 1W	01121	GB 1041	6	2		
0690-1231	R:FXD COMP 12K OHMS 10% 1W	01121	GB 1231	1	1		
0690-1521	R:FXD COMP 1500 OHMS 10% 1W	01121	GB 1521	1	1		
0690-1531	R:FXD COMP 15K OHMS 10% 1W	01121	GB 1531	2	1		
0690-1551	R:FXD COMP 1.5M OHMS 10% 1W	01121	GB 1551	1	1		
0690-2221	R:FXD COMP 2200 OHMS 10% 1W	01121	GB 2221	3	1		

See introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

Stock No.	Description	Mfr.	Mfr. Part No.	TQ	RS		
0690-2231	R:FXD COMP 22K OHMS 10% 1W	01121	GB 2231	2	1		
0690-2721	R:FXD COMP 2700 OHMS 10% 1W	01121	GB 2721	4	1		
0690-2741	R:FXD COMP 270K OHMS 10% 1W	01121	GB 2741	1	1		
0690-3301	R:FXD COMP 33 OHMS 10% 1W	01121	GB 3301	1	1		
0690-3921	R:FXD COMP 3900 OHMS 10% 1W	01121	GB 3921	3	1		
0690-3931	R:FXD COMP 39K OHMS 10% 1W	01121	GB 3931	1	1		
0690-4711	R:FXD COMP 470 OHMS 10% 1W	01121	GB 4711	1	1		
0690-4721	R:FXD COMP 4700 OHMS 10% 1W	01121	GB 4721	3	1		
0690-4731	R:FXD COMP 47K OHMS 10% 1W	01121	GB 4731	2	1		
0690-5631	R:FXD COMP 56K OHMS 10% 1W	01121	GB 5631	1	1		
0690-8231	R:FXD COMP 82K OHMS 10% 1W	01121	GB 8231	1	1		
0692-1035	R:FXD COMP 10K OHMS 5% 2W	01121	HB 1035	4	1		
0692-5125	R:FXD COMP 5100 OHMS 5% 2W	01121		1	1		
0693-1531	R:FXD COMP 15K OHMS 10% 2W	01121	HB 1531	1	1		
0693-2221	R:FXD COMP 2200 OHMS 10% 2W	01121	HB 2221	2	1		
0693-2231	R:FXD COMP 22K OHMS 10% 2W	01121	HB 2231	2	1		
0693-2721	R:FXD COMP 2700 OHMS 10% 2W	01121	HB 2721	1	1		
0693-2731	R:FXD COMP 27K OHMS 10% 2W	01121	HB 2731	2	1		
0693-3321	R:FXD COMP 3300 OHMS 10% 2W	01121	HB 3321	1	1		
0693-4721	R:FXD COMP 4700 OHMS 10% 2W	01121	HB 4721	2	1		
0693-4731	R:FXD COMP 47K OHMS 10% 2W	01121	HB 4731	2	1		
0693-8231	R:FXD COMP 82K OHMS 10% 2W	01121	HB 8231	1	1		
0727-0124	R:FXD DEPC 3000 OHMS 1% 1/2W	19701	DC 1/2CR5 3K 1% 1W	1	1		
0727-0170	R:FXD DEPC 18K OHMS 1% 1/2W	19701	DC 1/2CR5	1	1		
0727-0173	R:FXD DEPC 20K OHMS 1% 1/2W	19701	DC 1/2CR5	1	1		
0727-0203	R:FXD DEPC 90K OHM 1% 1/2W	19701	DC 1/2B R5	3	1		
0727-0209	R:FXD DEPC 108K OHM 1% 1/2W	19701	DC 1/2A R5	1	1		
0727-0216	R:FXD DEPC 136.7K OHM 1% 1/2W	19701	DC 1/2 R5	8	2		
0727-0217	R:FXD DEPC 140K OHM 1% 1/2W	19701	DC 1/2B R5	2	1		
0727-0218	R:FXD DEPC 180K OHM 1% 1/2W	19701	DC 1/2C R5	3	1		
0730-0072	R:FXD DEPC 123K OHMS 1% 1W	19701	DC1 R5	1	1		
0730-0075	R:FXD DEPC 160K OHMS 1% 1W	19701	DC1 R5	1	1		
0730-0077	R:FXD DEPC 181K OHMS 1% 1W	19701	DC1 R5	1	1		
0730-0079	R:FXD DEPC 216.3K OHMS 1% 1W	19701	DC1 R5	1	1		
0730-0085	R:FXD DEPC 316K OHMS 1% 1W	19701	DC1 R5	1	1		
0763-0004	R:FXD MET FLM 23K OHMS 2% 2W	07115	S 25	1	1		
0767-0008	R:FXD MET FLM 10K OHMS 5% 3W	07115	LPI 3	1	1		
0767-0011	R:FXD MET FLM 20K OHMS 5% 3W	07115	LPI 3	1	1		
0770-0002	R:FXD MET FLM 2400 OHMS 5% 4W	07115	LPI 4	1	1		
0771-0003	R:FXD MET FLM 5000 OHMS 10% 4W	07115	LPI 4	2	1		
0811-0006	R:FXD WW 5000 OHMS 1% 5W	91637	RS 5	1	1		
0818-0010	R:FXD WW 2000 OHMS 5% 30W	94310	OR-30	1	1		
0818-0012	R:FXD WW 4500 OHM 5% 40W	12697	TYPE8ZT	1	1		
0818-0014	R:FXD WW 1000 OHMS 5% 40W	94310	TYPE OR 40/1000	1	1		
0839-0006	RT: 10 OHMS 10%	24446	2D 754	2	2		
1250-0118	CONNECTOR:BNC	91737	8427	3	1		
1251-0006	CONNECTOR:MALE 16-CONTACT	02660	26-4100-16P	1	1		
1251-0007	CONNECTOR:FEMALE 16-PIN	02660	264200-16S	2	1		
1400-0007	FUSEHOLDER	75915	342003	1	1		
1450-0027	LAMPHOLDER:BAYONET	72619	810B-1	1	1		

See introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

Stock No.	Description	Mfr.	Mfr. Part No.	TQ	RS		
1901-0028	DIODE SILICON PIV 400V I AVGE 0.75A	28480	1901 0028	16	16		
1901-0033	SEMICON DEVICE DIODE 1N485B	07910	1N485B	5	5		
1910-0011	DIODE GERMANIUM 5MA AT 1V 60 PIV	28480	1910 0011	30	30		
1921-0010	ELECTRON TUBE: 12B4A TRODE 9 PIN MIN	33173	12B4A	8	8		
1923-0001	ELECTRON TUBE: 5654 PENTODE HP	33173	5654	2	2		
1923-0002	ELECTRON TUBE: 5725 PENTODE	33173	5725	8	8		
1923-0017	ELECTRON TUBE: 6AH6 PENTODE	33173	6AH6	3	3		
1923-0028	ELECTRON TUBE: 6CB6A PENTODE	86684	6CB6A	2	2		
1932-0008	ELECTRON TUBE: TWIN TRODE 9 PIN MINIAT	28480	1932 0008	4	4		
1932-0009	TUBE:ELECTRON 5965	33173	5965	8	8		
1932-0016	ELECTRON TUBE: 7119 DUAL TRIODE	73445	7119	1	1		
1932-0023	ELECTRON TUBE: 6J6 DOUBLE TRIODE	86684	6J6A	1	1		
1932-0027	ELECTRON TUBE: 12AT7 DUAL TRIODE	00001	12AT7	2	2		
1932-0030	ELECTRON TUBE: 12AX7 DUAL TRIODE	86684		1	1		
1933-0003	ELECTRON TUBE: 6BH8 TRIODE PENTODE	86684	6BH8	3	3		
1933-0004	ELECTRON TUBE: 6U8 OR 6U8A TRIODE PENTODE	33173	6U8	1	1		
1940-0001	ELECTRON TUBE: 5651 VOLTAGE REFERENCE	86684	5651	1	1		
1970-0003	TYPE 6700 MAGNETIC BEAM SWITCHING TUBE	83594	6700	4	4		
2100-0030	R:VAR COMP 250K 10% CWLOG 2W	28480	2100 0030	1	1		
2100-0044	R:VAR COMP 50K OHMS 10% 2W	28480	2100 0044	1	1		
2100-0093	R:VAR COMP 20K OHMS 20% LIN 1/5W	28480	2100 0093	1	1		
2100-0094	R:VAR COMP 50K OHMS 30% LIN 1/5W	28480	2100 0094	9	2		
2100-0095	R:VAR COMP 100K OHMS 30% LIN 1/5W	28480	2100 0095	1	1		
2100-0144	R:VAR COMP 250K OHM 30% LIN 1/5W	28480	2100 0144	1	1		
2100-0154	R COMP 1000 OHM 30% LIN 3/10W	28480	2100 0154	1	1		
2100-0177	R:VAR DUAL 2X100K 20% LIN 2W	28480	2100 0177	1	1		
2110-0002	FUSE:CARTRIDGE 2 AMP 3 AG	75915	312.002	2	20		
2110-0023	FUSE:CARTRIDGE 6.25 AMP 250V SLOW BLOW	71400	MDF 6.25	1	10		
2140-0008	LAMP GLOW NE-2 NEON	24455	NE2	4	4		
2140-0009	LAMP INCANDESCENT 6-8V .15 AMP	24455	47	1	1		
3100-0147	SWITCH-LEVER: 3 POS	28480	3100 0147	1	1		
3100-0178	SWITCH-ROTARY: 5 POS 1 SECT	28480	3100 0178	1	1		
3100-0179	SWITCH-ROTARY: DUAL CONCENTRIC 10 POS	28480	3100 0179	4	1		
3101-0005	SWITCH TOG DPDT JAN #ST22N	04009	95691	1	1		
3101-0011	SWITCH SLIDE DPDT 0.5 AMP 125 VDC	42190	4603	1	1		
3101-0014	SWITCH PUSHBUTTON SPDT BREAK BEFORE MAKE	82389	4S-1106	1	1		
3101-0017	SWITCH TOG DPDT 10 AMP 250V	04009	82611	1	1		
3103-0007	SWITCH: THERMOSTAT SPDT	82647	20410418 191	1	1		
3140-0006	MOTOR:AC 4 POLE 115 VAC 60 CYCLES 1700RPM	83821	MODEL 103 1465	1	1		
3150-0002	OIL:AIR FL.WATER SOLUABLE OIL	82866	SN 411	1	1		
3150-0009	FL AIR 10 X 10 X 7/8	28480	3150 0009	1	1		
5248-60G	COIL: 10.5UH	28480	5248-60G	1	1		
8120-0015	CABLE:POWER	70903	KH3981/PH70/7.5FT	1	1		
9100-0099	T POWER	28480	9100 0099	1	1		
9100-0100	T POWER	28480	9100 0100	1	1		
9130-0008	TRANSFORMER:PULSE	28480	9130-0008	2	1		
9140-0009	COIL VAR RF 50-100 UHY	28480	9140 0009	2	1		
9140-0027	COIL FXD RF 35 UHY	28480	9140 0027	2	1		
9140-0029	COIL:RF CHOKE 100UH 2.6 OHMS	99848	3100-15-101	8	2		
9140-0031	COIL FXD RF 75 UHY	28480	9140 0031	4	1		

See introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

Stock No.	Description	Mfr.	Mfr. Part No.	TQ	RS		
9140-0044	COIL VAR 165 UHY	28480	9140 0044	1	1		
9190-0002	DELAY LINE 0.5 U-SEC. 1700 IMP.	28480	9190-0002	1	1		
218A-40C	DIAL ASSBY	28480	218A-40C	1	1		
218A-60B	TRANSFORMER:PULSE RED	28480	218A-60B	1	1		
218A-60C	TRANSFORMER:PULSE YELLOW	28480	218A-60C	3	1		
218A-60D	TRANSFORMER:PULSE GREY	28480	218A-60D	3	1		
218A-60E	TRANSFORMER:PULSE GREEN	28480	218A-60E	2	1		
AC4-10	LAMP:NEON AGED, SELECTED, DOT ON + LEAD	28480	AC4-10	1	1		
G-29F-85	SEMICON DEVICE:DIODE IN55	28480	G-29F-85	6	6		
G-31G-15A	SEMICON DEVICE:DIODE SILICON	28480	G-31G-15A	2	2		
G-31G-27H	SEMICON DEVICE:DIODE 27VOLT	28480	G-31G-27H	1	1		
G-76-D	CONNECTOR:FEMALE 9-PIN PC	28480	G-76D	6	2		
G-84-E	LAMP:NEON	28480	G-84E	4	4		
G31G-8A	SEMICON DEVICE:DIODE	28480	G-31G-8A	3	3		

See introduction to this section

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 2 of 2)

CODE NO.	MANUFACTURER	ADDRESS
73734	Federal Screw Products Co.	Chicago, Ill.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	The General Industries Co.	Elyria, Ohio
73905	Jennings Radio Mfg. Co.	San Jose, Calif.
74455	J. H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	R.F. Products Division of Amphenol-Borg Electronics Corp.	Danbury, Conn.
74970	E. F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75173	Jones, Howard B., Division of Cinch Mfg. Corp.	Chicago, Ill.
75378	James Knights Co.	Sandwich, Ill.
75382	Kulka Electric Corporation	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Ill.
75915	Littelfuse Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co.	Erie, Pa.
76210	C. W. Marwedel	San Francisco, Calif.
76433	Micamold Electronic Mfg. Corp.	Brooklyn, N.Y.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76493	J. W. Miller Co.	Los Angeles, Calif.
76530	Monadnock Mills	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio
76854	Oak Manufacturing Co.	Crystal Lake, Ill.
77068	Bendix Pacific Division of Bendix Corp.	No. Hollywood, Calif.
77221	Phaostron Instrument and Electronic Co.	South Pasadena, Calif.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
77342	Potter and Brumfield, Div. of American Machine and Foundry	Princeton, Ind.
77630	Radio Condenser Co.	Camden, N.J.
77638	Radio Receptor Co., Inc.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
78189	Shakeproof Division of Illinois Tool Works	Elgin, Ill.
78283	Signal Indicator Corp.	New York, N.Y.
78471	Tilley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78790	Transformer Engineers	Pasadena, Calif.
78947	Ucinite Co.	Newtonville, Mass.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80031	Mepco Division of Sessions Clock Co.	Morristown, N.J.
80120	Schnitzer Alloy Products	Elizabeth, N.J.
80130	Times Facsimile Corp.	New York, N.Y.
80131	Electronic Industries Association Any brand tube meeting EIA standards	Washington, D.C.
80207	Unimax Switch, Div. of W. L. Maxson Corp.	Wallingford, Conn.
80248	Oxford Electric Corp.	Chicago, Ill.
80294	Bourns Laboratories, Inc.	Riverside, Calif.
80411	Acro Div. of Robertshaw Fulton Controls Co.	Columbus 16, Ohio
80486	All Star Products Inc.	Defiance, Ohio
80583	Hammerlund Co., Inc.	New York, N.Y.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
81030	International Instruments, Inc.	New Haven, Conn.
81312	Winchester Electronics Co., Inc.	Norwalk, Conn.
81415	Wilkor Products, Inc.	Cleveland, Ohio
81453	Raytheon Mfg. Co., Industrial Components Div., Industr. Tube Operations	Newton, Mass.
81483	International Rectifier Corp.	El Segundo, Calif.
81860	Barry Controls, Inc.	Watertown, Mass.
82042	Carter Parts Co.	Skokie, Ill.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Allen B. DuMont Labs., Inc.	Clifton, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod. Inc., Electronic Tube Div.	Emporium, Pa.
82376	Astron Co.	East Newark, N.J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals and Controls, Inc., Div. of Texas Instruments, Inc., Spencer Prods.	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Manufacturing Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83053	Western Washer Mfr. Co.	Los Angeles, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83086	New Hampshire Ball Bearing, Inc.	Peterborough, N.H.
83125	Pyramid Electric Co.	Darlington, S.C.
83148	Electro Cords Co.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Union, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.
83501	Gavitt Wire and Cable Co., Div. of Amerace Corp.	Brookfield, Mass.
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
84171	Arco Electronics, Inc.	New York, N.Y.
84396	A. J. Glesener Co., Inc.	San Francisco, Calif.
84411	Good All Electric Mfg. Co.	Ogallala, Neb.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85454	Boonton Molding Company	Boonton, N.J.
85471	A. B. Boyd Co.	San Francisco, Calif.
85474	R. M. Bracamonte & Co.	San Francisco, Calif.
85660	Koiled Kords, Inc.	New Haven, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86197	Clifton Precision Products	Clifton Heights, Pa.
86684	Radio Corp. of America, RCA Electron Tube Div.	Harrison, N.J.
87216	Philco Corp. (Lansdale Division)	Lansdale, Pa.
87473	Western Fibrous Glass Products Co.	San Francisco, Calif.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
88220	Gould-National Batteries, Inc.	St. Paul, Minn.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
89636	Carter Parts Div. of Economy Baler Co.	Chicago, Ill.
89665	United Transformer Co.	Chicago, Ill.
90179	U.S. Rubber Co., Mechanical Goods Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91260	Connor Spring Mfg. Co.	San Francisco, Calif.
91345	Miller Dial & Nameplate Co.	El Monte, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Brothers,'Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Nebr.
91662	Elco Corp.	Philadelphia, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Calif.
91921	Minneapolis-Honeywell Regulator Co., Micro-Switch Division	Freeport, Ill.
92196	Universal Metal Products, Inc.	Bassett Puente, Calif.
93332	Sylvania Electric Prod. Inc., Semiconductor Div.	Woburn, Mass.
93369	Robbins and Myers, Inc.	New York, N.Y.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
93983	Insuline-Van Norman Ind., Inc. Electronic Division	Manchester, N.H.
94144	Raytheon Mfg. Co., Industrial Components Div., Receiving Tube Operation	Quincy, Mass.
94145	Raytheon Mfg. Co., Semiconductor Div., California Street Plant	Newton, Mass.
94148	Scientific Radio Products, Inc.	Loveland, Colo.
94154	Tung-Sol Electric, Inc.	Newark, N.J.
94197	Curtiss-Wright Corp., Electronics Div.	East Paterson, N.J.
94310	Tru Ohm Prod. Div. of Model Engineering and Mfg. Co.	Chicago, Ill.
94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.
95236	Allies Products Corp.	Miami, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	New York, N.Y.
95264	Lerco Electronics, Inc.	Burbank, Calif.
95265	National Coil Co.	Sheridan, Wyo.
95275	Vitramon, Inc.	Bridgeport, Conn.
95354	Methode Mfg. Co.	Chicago, Ill.
95987	Weckesser Co.	Chicago, Ill.
96067	Huggins Laboratories	Sunnyvale, Calif.
96095	Hi-Q Division of Aerovox	Olean, N.Y.
96256	Thordarson-Meissner Div. of Maguire Industries, Inc.	Mt. Carmel, Ill.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96330	Carlton Screw Co.	Chicago, Ill.
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Calif.
97464	Industrial Retaining Ring Co.	Irvington, N.J.
97539	Automatic and Precision Mfg. Co.	Yonkers, N.Y.
97966	CBS Electronics, Div. of C.B.S., Inc.	Danvers, Mass.
98141	Axel Brothers Inc.	Jamaica, N.Y.
98220	Francis L. Mosley	Pasadena, Calif.
98278	Microdot, Inc.	So. Pasadena, Calif.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98405	Carad Corp.	Redwood City, Calif.
98734	Palo Alto Engineering Co., Inc.	Palo Alto, Calif.
98821	North Hills Electric Co.	Mineola, N.Y.
98925	Clevite Transistor Prod. Div. of Clevite Corp.	Waltham, Mass.
98978	International Electronic Research Corp.	Burbank, Calif.
99109	Columbia Technical Corp.	New York, N.Y.
99313	Varian Associates	Palo Alto, Calif.
99515	Marshall Industries, Electron Products Division	Pasadena, Calif.
99707	Control Switch Division, Controls Co. of America	El Segundo, Calif.
99800	Delevan Electronics Corp.	East Aurora, N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99934	Renbrandt, Inc.	Boston, Mass.
99942	Hoffman Semiconductor Div. of Hoffman Electronics Corp.	Evanston, Ill.
99957	Technology Instrument Corp. of Calif.	Newbury Park, Calif.

THE FOLLOWING H-P VENDORS HAVE NO NUMBER ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK.

0000F	Malco Tool and Die	Los Angeles, Calif.
0000I	Telefunken (c/o American Elite)	New York, N.Y.
0000M	Western Coil Div. of Automatic Ind., Inc.	Redwood City, Calif.
0000N	Nahm-Bros. Spring Co.	San Leandro, Calif.
0000P	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
0000T	Texas Instruments, Inc. Metals and Controls Div.	Versailles, Ky.
0000U	Tower Mfg. Corp.	Providence, R.I.
0000W	Webster Electronics Co. Inc.	New York, N.Y.
0000X	Spruce Pine Mica Co.	Spruce Pine, N.C.
0000Y	Midland Mfg. Co. Inc.	Kansas City, Kans.
0000Z	Willow Leather Products Corp.	Newark, N.J.
000AA	British Radio Electronics Ltd.	Washington, D.C.
000BB	Precision Instrument Components Co.	Van Nuys, Calif.
000CC	Computer Diode Corp.	Lodi, N.J.
000EE	A. Williams Manufacturing Co.	San Jose, Calif.
000FF	Carmichael Corrugated Specialties	Richmond, Calif.
000GG	Goshen Die Cutting Service	Goshen, Ind.
000HH	Rubbercraft Corp.	Torrance, Calif.
000II	Birtcher Corporation, Industrial Division	Monterey Park, Calif.
000KK	Amatom	New Rochelle, N.Y.
000LL	Avery Label	Monrovia, Calif.
000MM	Rubber Eng. & Development	Hayward, Calif.
000NNA	"N" D Manufacturing Co.	San Jose 27, Calif.
000PP	Atohm Electronics,	Sun Valley, Calif.
000QQ	Cooltron	Oakland, Calif.
000RR	Radio Industries	Des Plaines, Ill.
000SS	Control of Elgin Watch Co.	Burbank, Calif.
000TT	Thomas & Betts Co., The	Elizabeth 1, N.J.

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WARRANTY

All our products are warranted against defects in materials and workmanship for one year from the date of shipment. Our obligation is limited to repairing or replacing products (except tubes) which prove to be defective during the warranty period. We are not liable for consequential damages.

For assistance of any kind, including help with instruments under warranty, contact your authorized hp Sales Representative for instructions. Give full details of the difficulty and include the instrument model and serial numbers. Service data or shipping instructions will be promptly sent to you. There will be no charge for repair of instruments under warranty, *except transportation charges*. Estimates of charges for non-warranty or other service work will always be supplied, if requested, before work begins.

CLAIM FOR DAMAGE IN SHIPMENT

Your instrument should be inspected and tested as soon as it is received. The instrument is insured for safe delivery. If the instrument is damaged in any way or fails to operate properly, file a claim with the carrier or, if insured separately, with the insurance company.

SHIPPING

On receipt of shipping instructions, forward the instrument prepaid to the destination indicated. You may use the original shipping carton or any strong container. Wrap the instrument in heavy paper or a plastic bag and surround it with three or four inches of shock-absorbing material to cushion it firmly and prevent movement inside the container.

GENERAL

Your authorized hp Sales Representative is ready to assist you in any situation, and you are always welcome to get directly in touch with Hewlett-Packard service departments:

CUSTOMER SERVICE

Hewlett-Packard Company
395 Page Mill Road
Palo Alto, California, U.S.A.
Telephone: (415) 326-1755
TWX No. PAL AL 117-U
Cable: "HEWPACK"

OR (In Western Europe)

Hewlett-Packard S.A.
54-54bis Route Des Acacias
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